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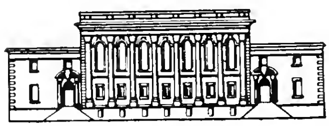

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People's Attitudes Toward Solar Energy and its domestic application

Senior Honors Thesis
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INTRODUCTION

As world energy demand and price in imported oil and natural gas increase, new and renewable energy resources, especially solar energy, will contribute to the solution of some serious economic, political and social problems for developed and developing nations.

Solar energy, as a peaceful and renewable energy source in the 80's should be fully appreciated and explored by most of the world's governments and major industrial organizations, on a much larger scale. As world energy demand increases, this will pose serious problems for both, developed and developing countries. The developed countries can invest in expensive technology to use alternative energies - nuclear, solar, geothermal for example - and can use energy more efficiently to restrain the growth of demand. Most developing nations have neither the financial resources nor the skilled labor and technical expertise to do this. While the measures taken in the developed world to reduce consumption of energy and oil will have a global impact, it is necessary for the developing countries to find solutions as well, by developing constructive energy policies, and making the most of their natural resources. So, "appropriate technology" should be related to local conditions, skills and initiative. The solar equipment should be easy to build and maintain in all countries. For instance, large power stations may be appropriate to urban areas and industrial centers in less-developed countries (LDCs), whereas for rural areas (where still by a far majority of the population of the Third World lives) softer, less centralized technologies for household or village use are in order.

Perhaps a very attractive energy technology that can become one of the most economically competitive source is solar energy in its direct solar heating for domestic hot water use. Solar space heating (especially of the

"passive" rather than "active" variety) may also become very competitive. Nevertheless, there are also other ways in which man can use solar energy, though they are more complicated. They include biomass, as wood, corn stalks, sugarcane and other plant materials which can be converted to alcohol (ethanol or methanol) or gas (methane) of which can be burned in a power generator. Satellite power stations can be constructed in space to take energy from the sun without atmospheric interference and beam it to the earth by microwave. Photovoltaic which is the use of solar cells to generate electricity, or, wind power and irrigation driven by the sun, are forms of solar energy as well.

It is true that some countries have more solar radiation than others and this is why different types of systems and components are required in each case. Thus, the point would be for the industrialized nations to orient those developing countries which have enough sun radiation toward not committing the same errors and starting new technologies. The developing countries - of which there are about 100 - cannot be neatly classified into one homogeneous group. They differ widely in their economic, social and political structures and their prospects for the future development. They also have a variety of economic bases. Bangladesh, Kenya and Tanzania are predominantly agricultural, whereas Guinea, Zaire and Sierra Leone are mineral exporters. Others are based on the export of oil - the OPEC countries and Mexico, for example - while others like South Korea and Brazil, are industrializing rapidly.

Despite these differences, the developing countries have certain common characteristics: for instance, Mexico (unlike France, Spain and Norway) has relatively low levels of income - with the exception of some OPEC or industrializing countries, such as Hong Kong and Taiwan. Also,

many LDCs have certain climatic, geographical and demographic features in common which help determine their present energy sources and demand. Their population is growing very rapidly, like Mexico's. According to the World Bank, 40 percent of their population is under 15 years of age (compared to 30 percent in the developed world), creating and enormous labor force in the future. As countries develop, most of the people in the rural areas move to the urban areas hoping to improve their standard of living. But because of their lack of education they really never integrate into the modern urban, pre-industrial societies that are emerging in those countries.

Other common characteristics of these countries (including Mexico) is that many fall into the sun belt region and the traditional use of non-commercial energy sources, such as dung and crop residues, is very typical. The Shell Group has estimated that wood, crop and animal residues provide over 60 percent of their total energy needs. Unfortunately, solar energy is still not seen by the majority of nations as an important energy source. There are still many doubts (outside some parts of the United States) about being able to use solar energy as one contributing source in an energy plan. But it should be pointed out that just during the past decade, interest in and funding of solar energy has increased and great progress has been achieved in a short period of time. However, much more needs to be done if solar energy is to make a world impact as an important energy source.

The economics of solar heating for domestic applications is dependent on the total annual heat load per residential unit and on available solar insolation. The annual heat load depends on the climate (number of heating degree-days per year), the building heat loss coefficient, and the domestic hot water demand. Nevertheless, in most locations, solar heating systems will require a conventional back-up system, thus, the idea would be for

solar energy to supplement, in an optimal solar conventional heating system, from 40 to 100 percent depending on the location, climatic factors and the price of conventional fuel.

With all this in mind, a survey was conducted by distributing a questionnaire among selected countries (Mexico, Spain, France and Norway), in order to get a study with an international perspective that will try to be representative of both, developed and developing nations. I hope that this study will help to promote further understanding of the problems and limitations involved, the nature of possible solutions and the amount of work that needs to be undertaken now. I believe the 80's will be full of promises for a brighter future.

I gratefully acknowledge the assistance and guidance of my adviser at Sweet Briar College, Dr. Langley Wood, in France, Dr. Jacques Vigneron, in the World Bank, Drs. M.A.S. Malik and Essam Mitwally, in England, Mr. Costis Stambolis, and in Mexico, my family. Without their help, I would have never been able to pursue this study.

METHOD

I was first introduced to the concept of solar energy and its domestic application while on my Junior Year Abroad in Paris by the French director of the environmental department in Paris VII University. After analyzing some of the actual energy problems that affect both developed and developing countries, we thought a survey would be a good way to finding out people's attitudes and knowledge toward this aspect of solar energy. (This study would be used in the university's research library as well). The survey emphasizes the role that information has when an alternative is being introduced as an energy option.

If people are informed about different energy alternatives they will be more aware and will be capable enough to contribute to diminish the world energy problem by making some changes in their lifestyles. For this reason and realizing that some countries have more problems than others, three countries were selected as samples to obtain results that would be considered characteristic of other nations as well. Norway, Spain, France and Mexico represent developed and developing nations from different continents with different background characteristics.

Writing a questionnaire is a difficult task, specially when time and money are two great limiting factors: I had only a few months to interview as many people as I could without any help. Originally, more countries were going to be included in the survey, but because of political problems in the French universities, the budget for this study was severely reduced.

To construct an efficient questionnaire: first, a pre-test was written and distributed among the kind of population that would be interviewed later for the real questionnaire. The questions have to be easy to read and understand, relevant and short. Then, the responses will be more accurate and

clear, and serve their purpose of giving to the surveyer a good idea of what has to be changed or included. This pre-test was done in Oslo, Norway, and it was distributed among twenty people within a period of three weeks.

After carefully analyzing the pre-test's results, the questions were re-arranged, altered, eliminated or added. The questionnaire was reduced substantially in length and the vocabulary used was changed. The questions were simplified and written in a less technical way. There are four sections in the questionnaire; three of them are questions on personal information, housing conditions, and opinion. A final section was an informative one concerning a description of a new French solar water heater.

The population selected included both men and women older than eighteen years. People were interviewed briefly, mainly in offices or homes, and in some schools and businesses, to try and get more cohesive points of view, specially because the number of respondents was relatively small. If they could respond the questionnaires right away, I generally waited for about 40 minutes, and if they could not, I gave them an addressed envelope so they could mail the answered questionnaire back to me. This was not the best or most efficient method to be used when gathering the questionnaires of a survey, but under the circumstances, it was a good way of doing it. This same method was followed in Spain, Mexico and France. In Spain and France (Madrid and Paris), thirty six out of fifty (72 percent) questionnaires were received, and in Mexico (Mexico City), forty eight (96 percent) out of fifty.

RESULTS

To determine people's attitudes toward solar energy, in particular, domestic solar water-heating, the most relevant and significant questions of the questionnaire are put together in different sections.

Fifty questionnaires were distributed in each of the capitals of Mexico, France and Spain. In Mexico City, a total of 48 questionnaires (96 percent) were answered, and only 36 (72 percent) were answered in Madrid and Paris. This is a relatively small number of samples, and the results could be subject to other possible interpretations. Let us keep in mind that this survey was done in the summer of 1980 and many things since then have probably changed. A more detailed analysis will be done in the final discussion of this study.

A total of nine tables and one diagram were put together according to the objective of the survey. For all of them several subdivisions were distinguished in order to simplify its interpretations, and to make it easier for the reader to understand.

In Tables IA to IE, the respondents' personal characteristics are analyzed. Overall, about 60 percent in each country were men, or at least there were more men who answered the questionnaire. Most of the women are married; men, depending on the country, are married or unmarried by a similar percentage, 50-70 percent more or less. These tables use the gender as a main point of relationship to compare the differences in other characteristics such as age. There are three age groups: most women fall into the first one (18-35 years old); men are more evenly distributed among the age groups, which perhaps indicates that they were more willing to cooperate with the study.

In Tables IIA to IID education and profession were put together because they both help determine each other's importance. Most of the people interviewed were selected carefully and had at least finished high school studies (for those women who might not work or not have a profession). It will help give us an idea of how much people could learn about solar energy through their education if information were more widely distributed. Interviewing people in the streets could have made the results fall into broader categories, and by selecting the population the results will be more homogeneous and coherent. Since the questionnaire was mainly distributed among offices and homes, most of the professions fall into the same groups. Those involved in business or construction are predominant, together with the lawyers.

Tables IIIA to IIID relate income and profession depending on the respondents' working sector: government or private. The number of people who work in either sector are almost equally divided. The lowest income sector is in Mexico (Mexico is a non-OPEC, oil exporting, industrializing nation). A majority of the respondents fall into the medium wage category. It was very difficult to relate education with income because some of the respondents did not answer very clearly. Since most of the respondents are professional people (not some of the housewives) the main difference will rely on their field of work, whether it is in construction or in business, does not matter, it is their general interest that counts. Very few doctors were interviewed, there were only 10 percent (5) of the total Mexican population interviewed (120). In Spain and France, for instance, there were more businessmen interviewed than in Mexico.

The household sector is emphasized because it is often the largest single sector in (many countries) when all fuels, commercial and non-commercial, are included. In general, the conventional belief assumes that

high income people will consume more energy because they have bigger homes or at least are in better condition than the lower income people to use more gasoline for cars, have heating and cooling systems, electricity, gas, etc.. Tables IVA and IVE intend to relate these two factors in order to try to determine energy consumption.

In Mexico City, 80 percent of the respondents (see Table IVE) live in a house, compared to Madrid (22 percent) or Paris (six percent). This probably means that even if Mexicans receive lower wages compared to the other two countries' capitals, the cost of living enables the first ones to have or afford a house, which is not the case for the two latter ones. Also, climate and weather conditions are more temperate in Mexico City, so people do not have the same heating and cooling expenses. The price of heating water is also three times lower than in Spain and about 13 times lower than in France. These are probably other reasons why people in these European cities live in apartment buildings.

Transportation and fuel consumption are relatively important ways of measuring energy and maybe even income. Most people that own a car have at least a medium level of income in order to afford private transportation which includes paying for their own gasoline. In Table V-A most people do have a car: 80 percent in Mexico City, 77 percent in Madrid, and 66 percent in Paris. This does not mean that the whole country has at least a car, but that in the big capitals, people do have a certain pattern of life.

In general, people who own a car would not use public transportation very frequently, but our results indicate the contrary, since specially in Paris people do use the bus and the metro system quite often. Maybe this is because the price of gasoline is quite high compared to the United States price: in France a gallon of gas costs the equivalent of $3.07. This factor,

and the efficiency of the public transportation system in Paris, are the reasons why people prefer not to use their own cars in the city. In Mexico gas is only about $.55 per gallon, and though in Mexico City public transportation is very good (The metro moves about 2.5 million people every day.*), it is still not enough for the nearly 16 million people the city has. Madrid has similar problems to those of the other two cities: it has a large population of around 10 million people, with public transportation in an old city, which is not enough for all. The price of gasoline averages $3.45 per gallon, so those who own a car (77percent of the respondents) also seem to use public transportation quite often.

The objective of any government's energy policy should be to reduce the country's dependence on petroleum supplies and to provide for its supply of energy under conditions of safety, compatible with the demands imposed by the international market competition. In order to reach these objectives it would be better to use several energy sources at the same time in order to obtain a more energy efficient system. This is why it is important to find out how much people know about different energy sources, specially about solar energy, before any definite policy can be determined. In Table VI-A it is logical, that depending on each country's main source, people would know about that particular source better than the other sources. For instance, in France the new program is to implement nuclear power generation, hence 77 percent of the respondents knew about it, whereas in Mexico only 16 percent knew about nuclear, and in Spain only 22 percent. Of course all these types of answers are relative to the extent that some people could have just heard about such particular source of energy, without necessarily

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* R & D Mexico (magazine) Dec., 1980 p. 12.

knowing how it really functions, and consequently they marked it as a source they knew about. As of the summer of 1980, solar energy was just starting to be more known on the public sector of some countries, so people knew little about it (only 25 percent overall), but in this coming decade, solar energy promises to be a very important source of energy which will be greatly developed, specially among the developing countries. Geothermal, eolian and biomass are not very well known by the Mexican respondents; but for the Spanish and the French they seemed to be better known, 13 percent and 25 percent (average) respectively. Hydroelectricity is a very important energy source in Mexico (32 percent of the answers) whereas in Spain only 16 percent and in France 27 percent. This might mean as well, that the respondents know about it though it was not as important as fossil fuels are (conventional sources of energy). As Table VI-A indicates, 62 percent of the Mexicans know about fossil fuels (specially petroleum), 55 percent in Spain, and 77 percent in France.

Often the location, size and age of a building, together with the size of a family (or household) may have important effects on total fuel consumption. Unfortunately, only very limited data on the quantities of fuel, especially non-commercial fuels, consumed by households is available. So, this survey will cover the cost of heating water and the water consumption in the questions. Thus, Table VII-A shows that in Mexico City about a third of the people live in each of the age of building categories. This probably means that it is an old city that has been growing and developing quite rapidly. Madrid and Paris have a bigger gap: for the first only 23 percent of the people live in relatively new buildings (one to seven years old), and 77 percent in older ones; and for the second one, only 11 percent live in the new buildings, 55 percent live in the buildings that are older than 30

years, and 34 percent in the buildings that are older than eight years.

Very few people live alone, either because people generally like to live with other people, or because it might be too expensive to live alone. In Mexico City, 60 percent of the respondents live with four to eight people (Table VII-C). In general, families tend to be of a larger number than in France (36 percent) or even Spain (55 percent). In Spain, there are 36 percent of the respondents who live with one to three people and in France, 62 percent. Maybe this indicates that because of the high cost of living and because of the small apartments, Parisians tend to have only one child, or live in much smaller groups.

Tables VIII-A to VIII-D and IX are people's opinions on different questions. Table VII-A refers to people's beliefs about efficiency of electrical power plants by rate of efficiency. It is important to determine if people do have at least an idea about the efficiency of electrical power plants. Most people in these three countries followed the same pattern of thought, this is: in Mexico, France and Spain, 100 percent responded that coal power plants have a 15 percent efficiency, which is the lowest percentage mentioned. Nuclear plants' responses varied more: in Mexico all 48 respondents thought that nuclear power plants have a 40 percent efficiency; in Spain, 20 respondents (54 percent) thought of a 30 percent efficiency rate, and 16 respondents (44 percent) thought of a 40 percent efficiency; and in France, six respondents (17 percent) thought of a 30 percent efficiency rate, and 30 (70 percent) thought of a 40 percent efficiency rate. For fuel power plants: in Mexico, 100 percent thought of a 40 percent efficiency rate, in Spain and France there was a more varied belief: in Spain, 10 respondents (27 percent) thought they have a 15 percent efficiency, 12 (33 percent) thought they have a 30 percent efficiency and 14 (40 percent) thought they

have a 40 percent efficiency. Twenty-six (72 percent) French thought they have a 30 percent efficiency and 10 (28 percent) thought they have a 40 percent efficiency rate.

Photosynthesis is the process by which the green plants are capable of converting inorganic materials into organic ones through the energy of the sun light. It is a highly efficient process which is considered to be simple but fundamental in nature cycles of life. In general people did have a quite good idea of this concept and its efficiency because they probably learned it in high school. See Table VIII-B.

Table VIII-C (question 27 of the questionnaire) is a difficult question to analyze because of the way the responses resulted. All power plants deposit thermal wastes in the atmosphere and rivers, but the question was intended specifically toward electric-nuclear plants. This is why we are surprised, for instance, when all Spanish people responded that these kinds of plants do not deposit more thermal wastes than the other power plants. Mexicans and French support this point by a big majority as well.

A very interesting question is certainly that of people's beliefs about the average proportion of energy productivity by energy sources in respondents' native country and in the world (Table VIII-D). This question has a great variety of answers. First, for nuclear electricity, of course French are well informed now that nuclear has a big role in their governmental policy, "France is going nuclear." Mexicans know that their country will definitely "go for oil," and also toward hydroelectricity as a back-up source. But Spain is the hardest to determine because of all the possibilities that might emerge for her in the next few months. The price of oil is very high, specially in European countries, so the apparent alternative sources might be nuclear, and solar wherever the conditions are good enough to install it.

At least 50 percent of the respondents believe in the success of nuclear power generation in their country.

Causes of death has always been an important issue, often blaming most of them to nuclear energy. This is why it is considered an important issue, that is part of the questionnaire, and which emphasizes that solar energy is a secure and peaceful means of obtaining energy that will be analyzed further in the discussion. But the results of Table IX show that people did not consider nuclear as a harmful energy source either. Death is caused by many other things as they demonstrated in their answers. Illnesses (heart diseases and cancer included) are people's biggest concerns and fears nowadays. This is why many of the questions had an interesting result. There could be many other reasons for it, like a lack of information or knowledge given to people; reasons that should at least be mentioned here.

Education is a very difficult issue to consider in a small survey like this one, specially because these three cities (and countries) have very different educational systems. (Table *) There is also one or two years difference between the students of the three countries, for instance in France, people obtain their doctorate, if they studied without taking any years off, at the age of 26, which is just a couple of years older than in the United States, Mexico or Spain. This is not the important point, it is the difference in the educational process where more differences should be distinguished. But the level of education, or the way people are educated should not be taken as a major point, or excuse to determine certain characteristics in the respondents' answers. This last table is subject to interpretations of all kinds, but it serves its general purpose of illustrating the differences of age between these educational systems.

DISCUSSION

In the past few years, a dramatic change has occurred in the ways nations perceive energy, especially the developed nations that no longer take the availability of fossil fuels for granted and in which nuclear power is no longer viewed as the only alternative toward solving the needs for lifetimes to come.

Many nations' first shock (especially for the United States), was the oil embargo of 1973 that was followed by long lines at gas stations, shortages of home heating oil, plant shutdowns due to natural gas curtailments, and a quintuple increase in fossil fuel prices. In the course of the 1970s the cost and availability of energy and particularly of oil, has become a worldwide concern. All countries have become dependent on petroleum products to maintain their transportations systems, industrial and agricultural production, national defense and other vital functions. Most of them depend on imported oil and natural gas, hence, a threat in international supply will affect national societies and the world economy. At the same time, the depletion of the world's oil resources is proceeding so fast that the transition to the other sources will be necessary now.

Energy shortages take many forms. Sudden rises in petroleum prices will affect all countries, especially because the use of energy in the world is very unbalanced. For instance, in "North-South", the W. Brandt report*, it is estimated that the consumption of energy per person in industrialized countries compared to middle-income and low-income countries is in the proportion of 100:10:1. One American uses as much energy as two Germans, three Japanese, six Yugoslavians, nine Mexicans, 19 Mlaysians, 53 Indians, 109

*North-South. A program for Survival. MIT Press. 1980. Report headed by W. Brandt. Chapter 10.

Sri Lankans or 1072 Nepalese. Also, all the fuel used by the Third World for all purposes is only slightly more than the amount of gasoline the North burns in its automobiles.

But the energy crisis itself took a long time to develop and will take a long time to be solved as well; it will always depend on each country's lifestyle and whatever changes people are willing to make. So, whatever is accomplished by 1985 will now be seen as the first step toward a more stable solution to some nations' energy needs.

Whenever a nation is really undergoing a severe energy problem a first step to be taken should be the conservation of energy, and then a switch to an alternative energy source. Research and development, and demonstration and commercialization of new energy sources, such as solar energy, should be the ultimate goal. For those developing nations (like Mexico and Spain) which are ready to undergo rapid changes, this could be a goal to follow. For instance, Mexico could use some of its oil money to develop solar technologies in some of the most needed rural regions where enough sunlight is available in order to improve certain aspects of the way people live there. If adequate energy policy and technology is exported from those experts who have experience with the new energy sources, materials could be manufactured in Mexico, by Mexicans who could also learn how to apply them and using their own resources to satisfy their particular needs.

Solar energy has several characteristics. Sunlight is available and virtually inexhaustible everywhere. It interacts as part of the environment in many ways which may be exploited to produce usable power. Briefly, these are some of the types of solar energy that could be used:

- Winds are caused by sunlight heating the air of various regions differently. Air warmed by the sun rises and cooler air flows in, creating

air currents with energy which can be used by wind machines to produce mechanical power (eolian). This power may be used directly -- to pump water for irrigation, for example -- or in a more elaborate process by driving a generator.

- Plants use sunlight directly to produce biomass. Trees or crop residues may be burned to produce heat or power, or may be used to produce energy-intensive products such as synthetic fuels, ammonia or methanol.

- Sunlight also heats the upper layers of the oceans while deep ocean waters remain significantly colder. A temperature differential of about 35°C between upper and deeper waters is not uncommon in some tropical areas. The differential; may be used to drive a heat engine to produce usable power.

- Sunlight is collected and concentrated through the use of solar collectors. Some of these collectors are designed to be used to heat hot water, to heat space in buildings, to provide heat for industrial processes, to cool through the use of absorption coolers, or to produce electricity by several thermodynamic processes.

Solar energy systems to heat water and heat and cool buildings seem to be the closest to commercialization and are expected to account for the majority of solar energy savings by 1985. Although solar is expected to displace some gas and oil as well, the assumption that solar will only displace electricity applies until the year 2000, but is probably conservative after 2000 when gas and oil probably will be even more expensive.

- Solar process heat systems for agriculture and industry are similar to the solar building systems except that the individual process heat systems are designed to meet much larger heat requirements and may provide heat at much higher temperatures.

Analysis of process heat applications includes all the major types of

fuel, but does not use explicitly detailed designs for the conventional systems. The conventional systems performance parameters reflect the highest reasonable efficiency levels for design with energy conservation and thereby probably result in an underestimate of solar impact.

- Several solar energy technologies are expected to be capable of providing centralized electric energy production, including wind energy conversion systems, solar thermal central receivers, photovoltaics, ocean thermal energy conversion systems and the direct combustion of biomass. But these technologies together with the production of synthetic fuels and products are still too expensive to be considered as an immediate alternative to be fully developed in a country. This is why domestic solar energy applications (water-heating, and space cooling and heating) are the main solar version of this study. Perhaps, in some years to come, the market competition will allow these other processes to become part of our lifestyle.

Solar energy can be a significant contribution now because gas and oil are getting more and more expensive and because the capital costs of nuclear and coal burning systems are still high. But if fuel and electricity prices were low, or if the energy demand was low, many of our current energy problems would be solved, and the need for solar energy and other energy sources would not be as necessary. In this case, the impact of solar energy could be delayed or reduced. Thus, reasonable changes in accelerating research and development (R&D), market response and other assumptions could result in a substantially higher growth of solar energy. Therefore, people's attitudes toward solar energy and its domestic application are important issues to consider because after all it is the people who make things possible and who will contribute in this changing process. By interviewing in

some developed nations (France and Norway) and some developing ones (Spain and Mexico), I tried to obtain a broader and representative perspective of people's opinions and knowledge of the subject (even if the number of questionnaires was relatively small).

The non-availability of enough data in some of the countries where this survey was done, made it quite difficult to interpret the results. The same questionnaire was written in three different languages (English, French and Spanish), so it is subject to some minor misinterpretations. English was used for the pre-test that was done in Oslo, Norway. As was expected, the pre-test led to many changes. First of all, the quality of the language that was used was relatively poor and not clear. Many unnecessary questions, which made it too long, were eliminated. Since the questionnaire was too technical and used a "scientific" vocabulary, it made the questions unclear and uneasy for the respondents. So, very often he had to think too much for some of the calculations required in the questions. Thus, the questions were re-written using a category system (process of elimination), where the respondent could estimate the consumption figures, for example, without having to give an exact figure. This change simplified the questionnaire and made it less time-consuming as well. So, more people mailed the questionnaire back this second time, which probably meant that they felt it was a simpler one. Perhaps, it was even more interesting than the pre-test questionnaire.

The figures in Table I-D indicate that 54 percent of the total population that was interviewed were women between 18-35 years old, 38 percent were women between 36-50 years old and 25 percent were women between 51-65 years old. There were 46 percent men between 18-35 years old, 62 percent men between 36-50 years old and 75 percent men between 51-65 years old of the total population interviewed. This does not mean that the women did

not want to answer, it probably resulted this way because, in general, more men worked in the offices where the survey was done. Another reason for this result could be, that if there were more women interviewed, maybe they just did not mail their questionnaires back to me. This last probability could indeed have happened because this survey had three very important limitations: money, time and interviewing system. The survey's budget was severely reduced because of political problems that occurred in the spring of 1980 in the Parisian universities, consequently things had to be done faster and in fewer countries than the ones that were originally planned. I also received no help from anyone when doing the actual interviews, which slowed down the survey and limited its number of respondents.

In her article "Changing Energy Usage for Household and Subsistence Activities," Irene Tinker concluded with a very interesting opinion - "women are the primary energy users of energy in the household and provide much of the energy needed in subsistence activities. Preconceptions about their economic roles have masked their daily work. Interventions to change energy use, whether for necessary or for substitutable fuels, must take into account the total time budget and roles that women play. Similarly, any attempt to change fuel type must consider the several functions which the present fuel performs. More needs to be known about the variety of fuels used in cooking, as well as the variety of human tasks that might be more efficiently done with other forms of energy. This information must be gathered from women, by women or children so that the replies are reasonably accurate. Interventions have the potential of great improvement of the human condition in many places, but only if the total world of women becomes an integral part of the planners' framework."*

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*UNITAR, June, 1980. Vol. V. No. 3, p. 6.

This article stressed the point of making a difference between men's and women's roles, their role in a household and energy consumption. This is just one example of the different ways of learning how we could look at things from different perspectives in order to analyze better all kinds of characteristics that are present in the tables of the survey's results. So, I will proceed with this discussion by presenting other authors' perspectives based on studies that were done similar to this one.

"Energy Future"* reports that "thousands of people in the United States are buying solar systems today but at this point the solar energy industry is an elitist phenomenon." The marketing manager of a leading solar firm described the 1977 consumer as a "man in his late forties or fifties, typically an engineer or an architect earning 40 to 50 thousand dollars a year. He buys equipment for status or philosophical reasons. Economics are not a factor." However, this profile is changing. Solar energy is also being adopted by some middle-income people in their thirties. Moreover, the size and character of the solar market will be expanded by a provision in the Military Construction Act of 1979, which stipulates that if "cost-effective", that is, if they can pay for themselves over the next 15 to 25 years, solar heating systems must be incorporated into all new military housing and 25 percent of remaining new military construction. But in order to make an important contribution, solar heating must become accepted by a much broader range of people, and basic household economics will be an important factor.

This is another reason why different professions were considered to be an important characteristic to explain some of the survey's results. Table II-C shows that in the three countries, those people involved in the construction field were the ones who returned more questionnaires. Taking each

*Energy Future. 1979. A report from the Harvard Business School. Ed. R. Stobaugh.

country's population separately there were: 20 percent architects and 17 percent engineers in Mexico, 11 percent architects and 11 percent engineers in Spain, and 20 percent architects and 10 percent engineers in France. If we look at Table II-D, of all the architects interviewed for example, 55 percent were Mexicans, 18 percent Spanish and 27 percent were French. Taking all the engineers, 26 percent were Spanish, 53 percent were Mexicans, and 21 percent were French.

All the figures mentioned above, in general, are bigger than those of the other professions. Perhaps this is because the people in the construction business are more aware of some of the new solar energy technologies (through publications) or even if not all of them might be very well informed, they demonstrated, at least, a certain curiosity in the field. To take advantage of this kind of interest, an important approach to make solar energy more popular would be to dispense more information to a broader group of people, to people in different areas such as business or even households. These people eventually will have to deal with all the new aspects involved in promoting a new "thing." Who knows, they might even have to change their lifestyles to an extent and eventually choose to use solar energy in their own homes and businesses, becoming involved in solar energy in a direct or indirect way.

Another trend nowadays should be that of teaching elementary solar energy principles in schools. Children and young people should be exposed to new ways of thinking and energy alternatives, because it is they, the coming generations, who will have to make and live through many changes. Their ways of living will have to evolve according to new demands, thus, they should be concerned with some of the energy problems that exist nowadays. Solar energy should not just be a dream to many anymore and as President

Carter said on Sun Day, 1978, "Solar energy works. We know it works. The only question now is how to cut costs."* But costs are not the only questions, powerful institutional barriers also impede the acceptance of solar heating by a wider range of people.

Nowadays, in the United States for example, the rate of return for investing in solar energy technology is still too low. This constitutes a critical economical obstacle since the United States was, until a few months ago, one of the only countries in the world where solar energy received economic incentives from their government. Even by conventional analysis, solar energy can often provide reasonable paybacks, but difficulties of analyzing solar energy by conventional methods are many and they bias the comparisons against solar energy. First, analysis must consider weather, technology, and the cost of fuel assumed in the comparison. Second, several considerations in solar energy's favor are often overlooked. To illustrate this point with an example (taken from "Energy Future", p. 192 - United States data available) of an installation of a solar hot water system with overnight storage capacity in an oil-heated home in Northern United States. Let us assume that the system costs $2,400, including installation and all accessories, and that it saves $200 a year on home heating-oil costs. Four different methods can be used to evaluate the rate of return:

1) $2,400 divided by $200; the payback is 12 years -- much higher than the five year payback required for wide national acceptance. Still, the system provides a good return, for at slightly over eight percent, the return is better than a savings account;

2) Consider taxes. The $200 saved per year can be regarded as tax free

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*Energy Future. A report from the Harvard Business School. 1979. p. 243

income, which can be very important if the homeowner is in a high bracket. In a 33 percent bracket, the return is equivalent to a pretax 12 percent return, and in a 50 percent bracket, 17 percent. Thus, the return would be better than from a high-yield bond;

3) Assume that fuel costs rise two percent faster than inflation, and that the system's life is 20 years; further assume an initial 20 percent down-payment and 20 additional mortgage payments. That is, visualize a system purchased at today's prices and saving energy tax-free at tomorrow's prices. The result is a straight 11 percent, which is a 24 percent pretax return for someone in the 33 percent bracket, and a 40 percent pretax return for someone in the 50 percent bracket;

4) Consider the benefits and costs to society at large, it must be noted that solar does not carry the external costs of coal or nuclear. It needs more person-hours per BTU of energy supplied than the conventional energy technologies. Furthermore, if an incremental barrel of imported oil costs $35, or three times the 1978 market cost, the real payback shrinks from 12 to four years - which is a very attractive investment. For a person in a 50 percent bracket, it amounts to a two year, pretax, simple payback.

This example shows clearly that solar energy is far more "economic" than is conventionally assumed. The greatest single barrier, however, is to get the homeowner to see beyond that 12-year payback.

But two other important economic barriers exist. One is the cost of borrowing money. An individual will have to pay interest rates up to 20 percent or higher to save a kilowatt through solar energy instead of having to add a kilowatt of capacity through utilities. Another is the installation of solar heating that may also impose a penalty in the form of increased property tax, a sore subject with homeowners all over the world

today.

Tables III-A to III-D relate income and working sector and Tables IV-A to IV-E relate income level with house conditions to try to determine, in Mexico, Spain and France, what people with different income levels, depending on their professions, could afford to do in order to change their lifestyles. Due to the circumstances those who already have a house built some years ago (Tables VII-A and VII-B) will have more problems in order to install their solar water heaters, for example. It would be much easier and economically feasible, for those who plan to build a new house that will follow the solar system's requirements.

If people were more informed, maybe they could even learn about installing and maintaining their own systems. (This idea was included in the pre-test's questionnaire - the French want to pursue this idea by offering some do-it-yourself type courses). Poor installation is a far greater problem than the reliability of the solar equipment itself. Although there is an abundance of solar firms, solar skills are in short supply. A solar engineer or architect with more than five years' experience is a rarity, sometimes non-existent in some countries.

But the weakest link in the chain is the solar installation technician, often a plumber with no experience in working with solar equipment. (This is the reason why, in the pre-test, a question was asked if people did some kinds of manual jobs at home). What happens then is that a general mood of consumer dissatisfaction over poor operating results could have a bad effect on the willingness of homeowners to take the risk of installing any type of solar equipment.

This brings us back to the subject of income distribution and education which are considered along this study to be very important limiting factors;

Figure 1

NUMBER OF "POOR" FAMILIES BY SECTOR AND TYPE OF WORKER: 1975[a/]

Sector and Type of Worker	Thousand Families			Percentage of Total Families			Average Income (dollars per year)		
	Total	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural
No Occupation	547	190	357	11.9	4.1	7.8	594	722	526
Agriculture	2,410	79	2,331	52.4	1.7	50.7	492	787	482
Owner	25	4	21	0.6	0.1	0.5			
Self-employed	1,522	30	1,492	33.0	0.6	32.4			
Non-salaried in family business	12	-	12	0.3	-	0.3			
Salaried employee	851	45	806	18.5	1.0	17.5			
Mining	26	15	11	0.5	0.3	0.2	1,037	958	1,152
Owner	-	-	-	-	-	-			
Self-employed	1	1	-	-	-	-			
Salaried employee	25	14	11	0.5	0.3	0.2			
Petroleum and Electricity	6	6	-	0.2	0.2	-	1,077	1,077	
Owner	-	-	-	-	-	-			
Self-employed	-	-	-	-	-	-			
Salaried employee	6	6	-	0.2	0.2	-			
Manufacturing	491	206	285	10.7	4.5	6.2	762	909	655
Owner	13	6	7	0.3	0.1	0.2			
Self-employed	210	43	167	4.6	1.0	3.6			
Salaried employee	268	157	111	5.8	3.4	2.4			
Construction	135	88	47	3.0	1.9	1.1	894	835	1,004
Owner	-	-	-	-	-	-			
Self-employed	40	23	17	0.9	0.5	0.4			
Salaried employee	95	65	30	2.1	1.4	0.7			
Commerce, Services, Transport	921	488	433	20.0	10.6	9.4	776	837	706
Owner	16	5	11	0.3	0.1	0.2			
Self-employed	373	180	193	8.1	3.9	4.2			
Salaried employee	532	303	229	11.6	6.6	5.0			
Government	52	39	13	1.1	0.9	0.2	851	1,015	360
Owner	-	-	-	-	-	-			
Self-employed	-	-	-	-	-	-			
Salaried employee	52	39	13	1.1	0.9	0.2			
Insufficient Information	11	10	1	0.2	0.2	-	536	523	649
Total	4,599	1,121	3,478	100.0	24.4	75.6	631	833	609
Unemployed	547	190	357	11.9	4.1	7.8			
Owner	54	15	39	1.2	0.4	0.8			
Self-employed	2,153	283	1,870	46.8	6.2	40.6			
Non-salaried in family business	13	1	12	0.3	-	0.3			
Salaried employee	1,832	632	1,200	39.8	13.7	26.1			

Source: Author's estimates from household budget survey data.

a/ Defined as families whose monthly income was less than 1,621 pesos.

World Bank Publications # 395. p. 21

especially if solar energy is to become more popular and available to all. In order to clarify this point a World Bank report "Income Distribution and Poverty in Mexico"* will be used as an example.

What could be done in a developing country such as Mexico, where income distribution is very unequal and the level of education, in general, is very low (or even non-existent), to try to explain the advantages of solar energy in its domestic use?

The share of the poorest 40 percent of the households is between eight-12 percent of the total. Changes in inequality in Mexico since 1963 have been small. Many Mexicans still live in poverty, as anyone who knows the country can attest. However, the rise in per capita incomes in the nation as a whole, combined with the more or less unchanged share of the lowest 40 percent, increased the real income of that stratum considerably -- perhaps 70-80 percent from 1963-1977, an annual rate of around four percent per year.

Taking the 1977 minimum wage as a poverty line, the percentage and absolute number of households whose incomes fell below the line have decreased in the last few years. As of 1977, only 20 to 30 percent of all households earned less than the minimum wage.

In 1975, the largest number of "poor" Mexican families -- 52 percent -- were in the agricultural sector (Fig. 1). Of these, 33 percent are listed as self-employed (ejidatarios or small proprietors) while 18.5 percent are listed as salaried (landless agricultural workers). Thus, the most important single group of the poor are land-mining peasants -- 1.5 million families -- and the second most important are the landless rural workers -- 850,000 families. These 2.4 million families are the core of Mexican poverty.

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*World Bank publication #395. June, 1980. Joel Bergsman.

They include 76 percent of all families in agriculture in Mexico.*

Figures two and three give more details on characteristics of poor families in Mexico, as estimated by a 1975 survey. Among the urban poor about two thirds of income is from wages and salaries, and about 20 percent from their own business; for the rural poor self-employment is just as important as wages and salaries; each accounts for about 45 percent of income (Fig. 2). Heads of poor families have very little formal education, especially in rural areas where 55 percent had no school at all and another 30 percent or more had less than four years. Overall, more than three fourths of the heads of the poor families had less than four years of schooling (Fig. 4).

Studies based on 1968 and 1975 surveys have identified education of the head of household as the variable most closely associated with income differences. In 1968, van Ginnekin found out that of five possible variables, the one accounting for the largest share of observed inequality in income was inequality in education. In this survey this variable is slightly observed because the people interviewed were selected considering their educational level.

Urban or rural location was second in importance, occupation and sector were third, and age was a distant last. In 1975, Vargas and Vera concluded the same in another study. But this education variable does not tell us to what degree more schooling is a cause of higher income.

Figure 5 shows the expenditure of poor families. Not surprisingly, about one half of it is on food and the share of the rest are on housing

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*Note: "poor" families are those households with incomes less than half of the estimated national mean Mex $1,621 per month, equivalent in purchasing power to approximately US $1,315 per year per family. Characteristics such as sector, occupation, and education refer to the head of the household.

Figure 2

SOURCES OF INCOME OF "POOR" FAMILIES: 1975

	Family Income (dollars per year)			Percentage of Total Family Income		
	Total	Urban	Rural	Total	Urban	Rural
Income from Work	559	745	497	91.6	89.4	92.4
Wages and salaries	325	566	247	53.3	68.0	45.9
Own business, non-agricultural	97	170	73	15.9	20.4	13.6
Own business, agricultural	137	12	178	22.5	1.4	33.1
Transfers	47	73	38	7.7	8.8	7.1
Buying and Selling of Assets, and Other	1	4	1	0.2	0.5	0.1
Total	610	833	538	100.0	100.0	100.0

Source: Author's estimates from household budget studies. Details may not add to totals because of estimating procedures.

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Figure 3

NUMBER OF "POOR" FAMILIES BY EDUCATION OF HEAD OF FAMILY: 1975

Years of Schooling	Thousand Families			Percentage of Total Families			Average Income (dollars per year)		
	Total	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural[a/]
No education	2,192	279	1,913	47.7	6.1	41.6	480	753	440
1 - 3	1,409	356	1,053	30.6	7.7	22.9	679	838	625
4 - 6	865	377	488	18.8	8.2	10.6	784	873	715
7 - 9	98	75	23	2.1	1.6	0.5	860	877	803
10 - 12	13	12	1	0.3	0.3	-	909	898	1,053
13 and more	17	17	0	0.4	0.4	-	925	925	-
Not specified	5	5	0.4	0.1	0.1	-	780	797	708
Total	4,599	1,121	3,478	100.0	24.4	75.6	609	833	537

Source: Author's estimate from household budget studies.

a/ The average incomes for rural families headed by persons with considerable education are subject to possibly large sampling area.

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Figure 4

NUMBER OF "POOR" FAMILIES, BY OCCUPATION OF HEAD OF FAMILY: 1975

	Thousand Families			Percentage of Total Families			Average Income (dollars per year)		
	Total	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural
No occupation	547	190	357	11.9	4.1	7.8	594	723	526
Professional and technical	35	29	6	0.8	0.6	0.2	692	813	75
Managers	17	7	10	0.4	0.2	0.2	972	1,145	859
White collar workers	38	26	12	0.8	0.5	0.3	995	955	1,083
Tradesmen and salesmen	377	171	206	8.2	3.7	4.5	701	740	667
Service workers	488	247	241	10.6	5.4	5.2	831	901	760
Agricultural workers	2,384	69	2,315	51.8	1.5	50.3	491	733	463
Industrial and handicraft workers	696	375	321	15.1	8.1	7.0	792	898	668
Not classified	16	8	8	0.4	0.2	0.2	551	566	538
Total	4,598	1,122	3,476	100.0	24.3	75.7	610	833	538

Source: Author's estimates from household budget studies.

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Figure 5

AVERAGE EXPENDITURES OF "POOR" FAMILIES, BY TYPE OF EXPENDITURE: 1975

	Expenditures (dollars per year)			Percentage Distribution (percent)		
	Total	Urban	Rural	Total	Urban	Rural
Food	667	815		53.1	45.1	57.2
Beverages	30	40		2.4	2.2	2.5
Tobacco	9	11	8	0.7	0.6	0.7
Housing	218	429	150	17.4	23.7	13.8
Domestic Services	2	6	-	0.2	0.3	-
Clothing	128	159	118	10.2	8.8	10.9
Transportation	43	78	39	3.4	4.3	3.6
Education	8	18	5	0.6	1.0	0.5
Medical Services	37	47	34	3.0	2.6	3.1
Other Services	72	125	56	5.7	6.9	5.2
Furniture	22	42	15	1.8	2.3	1.4
Home Appliances	8	19	4.5	0.6	1.1	0.4
Vehicles	4	5	3.3	0.3	0.3	0.3
Other Expenditures	7	14	4	0.6	0.8	0.4
Total	1,255	1,808	1,084	100.0	100.0	100.0

Source: Author's estimates from household budget studies.

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and clothing. All other items account for about 20 percent of expenditures; not a very small amount for what are largely discretionary expenditures.

The results of three of Mexico's biggest problems: rapid population growth (up to 3.3 percent per year), neglect of the productivity of a large part of the agricultural labor force, and a bias in favor of capital-intensive production was to maintain enlarge wide differences in labor productivity among different parts of the Mexican economy.

The only way to ameliorate poverty in Mexico must come through a program that would raise the low productivity by combining properly the increasing human capital of the poor, their physical or financial capital, or changing the kind of work they do or the relative prices of what they produce. Actually, poverty in Mexico turns out to look like poverty in virtually every other middle-income country that has much of it. It is mostly in rural areas, and mostly among people who are not only economically but also socially and culturally different from their more affluent compatriots. It exists in countries that exploited agriculture to finance industrialization, by lowering the price of agriculture's products relative to the price of manufactures. It exists in "depressed areas."

Another obstacle for the development of solar energy in its domestic application is legal uncertainty. According to Energy Future* this is the reason why lawyers should always be informed about all the pros and cons of solar energy (see Tables II-C and II-D). One of the main risks (in the United States) associated with installing solar energy is the loss of access to the sun. Except for New Mexico, the sun is not a transferable property

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*Energy Future. 1979. p. 244.

right in the United States. The sun's rays strike solar collectors in the United States at an average angle of 35^{o} (depending on the location, plus or minus 20^{o}). Consequently, a potential solar buyer must analyze the growth of the trees, the construction of a high building, for example, before investing money.

Another concern that could block solar heated homes is related to the electric utilities that are used as a backup supply. Utilities can see solar heating competing with their own role as producer and converter of energy. Thus, many utilities show indifference or hostility to solar energy conservation. But when solar becomes more significant, utilities will have to become involved in its implementation. Their role should be that of maintainance and installation and not of selling the equipment. Utilities should play a pivotal marketing role in order for solar energy to be adopted and accepted.

According to M. A. Maidique in his "Solar America" chapter * only economic and institutional barriers are stopping solar energy from being adopted by people. Solar space and water heating could provide three million barrels of oil equivalent daily by 2000.

So, the way to give solar heating a chance in the marketplace against conventional sources is through: 1) economic incentives that promote the refinement and dispersion of solar products and skills, for example, a federal tax incentive. So, as in the United States, the 20-30 percent (1978) tax credit should go to 50-60 percent so that the 12-year payback is reduced. This incentive would encourage manufacturers and distributors. 2) Building codes should be reformed to facilitate action by state legislatures and city councils.

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*Energy Future, 1979. p. 231-269.

Individuals and companies are more risk-averse than society as a whole, and information generated by an installation that does not work is often of less use to the innovator who failed than it is to society. Therefore, solar energy deserves and needs greater governmental assistance. R. Stobaugh and D. Yergin (1979) suggested that in the United States, for example, solar users should receive an offsetting payment equal to about 60 percent of installation costs. This is especially justified for the smaller solar units for hot water that would be located on site since they can make an important contribution fairly quickly.

Instead of supporting the high-technology programs (like the power-tower) that have little potential in this century, the government should help homeowners who are short of capital and information, and averse to risk. For new homes, office buildings, and factories a large subsidy also would likely prove effective. Again, as with conservation, a considerable long-term education campaign is needed. For example, solar heating will prove more cost effective if it is used in buildings where a conservation effort has already been undertaken. This is why it was interesting to know in what kind of buildings respondents in the three countries live, in order to be able to determine what kind of energy options the public in general has (see Tables VII A and VII B).

Considering how many people of the survey work in the governmental or private sector could help determine what people's attitudes toward solar energy might be. Table III B shows almost equal distribution in both sectors: in Mexico there were 44 percent, of the total number of people interviewed, who worked in the governmental sector, while in Spain only 26 percent and in France 30 percent. For the private sector there were: in Mexico 36 percent, in Spain 33 percent and in France 31 percent. (These figures are taken

comparing one nation to another.) But the gap within the same country becomes bigger in Table III-A where in Mexico 42 percent worked in the government and 45 percent respondents worked in the private sector (17 percent were housewives). In Spain, there were 33 percent working for the government and 56 percent in the private sector (22 percent were housewives), and in France, 38 percent were working in the government and 62 percent in the private sector (10 percent of the private sector are housewives).

Knowing where people work could help determine what needs to be done, where, and by whom as soon as possible. Depending on the country, maybe it is the government which should facilitate some credit to those people who are interested in saving energy by using solar energy in their homes. In other countries, maybe the private sector could have a better alternative. However, this point will not be discussed here. It is a subject that should be treated by a specialist in economic and marketing matters.

Household energy consumption is also a very important point to consider. The income levels within each country will, in many cases, determine house conditions which in turn affect energy consumption. We have to remember that the survey was done in big capitals, so the results may not be characteristic of the whole country. Consumption of conventional energy sources is typical in urban areas such as commercial fuels: oil, coal and electricity; whereas in the rest of the country, specially in rural areas it would be that of non-conventional (or non-commercial) fuels, such as firewood, animal dung and crop residues which are burned as fuel.

It has been proven in studies, such as the Rand study on "Household energy use in NON-OPEC developing countries" (May 1980), that fuel consumption within a country varies across households at different income levels.

The income elasticity of fuel consumption (see Fig. 6 for details) which measures the extent by which fuel use varies with income, can be estimated only when the data permits it. Their results indicate that the elasticity of consumption of all fuels combined is in the range of 0.6 to 0.8, thus, every 10 percent increase in household income is generally associated with a six to eight percent increase in household consumption of all fuels combined. In urban areas specially, the elasticity of consumption of commercial fuels is much higher than that of non-commercial fuels; while in some rural areas the two fuel figures are more nearly equal. It is clear though, that fuel consumption increases noticeably among higher income households within each country. Electricity and gas consumption, in particular, increase dramatically among higher income families.

Households account for an average of about 45 percent of the developing countries' total energy consumption, but only 10-20 percent of their commercial energy consumption, according to a World Bank report of August 1980 (p. 55). Households in developing countries use energy mainly for cooking, with a small component for lighting. Space heating and cooling become significant only at the upper income levels, except in countries with severe winters. In the United States, by contrast, the heating and cooling of residential buildings alone accounts for 22.5 percent of total energy consumption.

To analyse energy consumption in the domestic sector the following information is required: disposable income per household; number of persons in household; monthly electricity and fuel consumption, giving energy type, and use, quantity and cost; and inventory of energy-consuming equipment in the household. This is why in the survey it was important not only to know about the income level related to the housing conditions (Table IV), but

Figure 6

ENERGY USE IN THE DOMESTIC SECTOR
MEXICO CITY, 1977

End Use	Energy Use per Family (BTUs × 10^6 per Year), by Income Level[a]				
	0-1000 (16.5%)[b]	1000-2500 (43.5%)[b]	2500-5000 (22.0%)[b]	5000-10,000 (11.0%)[b]	Over 10,000 (7.0%)[b]
Transportation	6	27	68	145	223
Household Use					
Cooking	10	10	10	10	10
Appliances	2	6	10	18	18
Heat	--	--	1	2	3
Other	11	12	12	22	28
Total	23	28	33	52	59
Public Services					
Lighting	--	3	4	4	4
Water	1	1	2	2	3
Garbage	--	--	--	1	1
Buildings[c]	3	3	3	3	3
Total	4	7	9	10	11
Total, all uses	33	62	110	207	293

SOURCE: McGranahan and Taylor (1977).

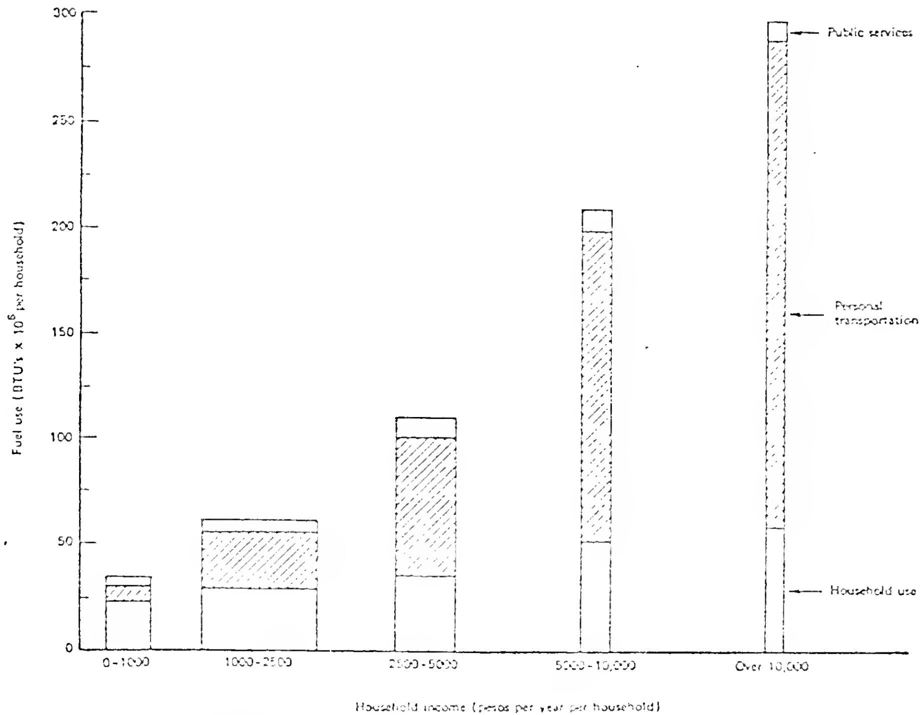
[a]1970 pesos per month.

[b]Percentage of total Mexico City households in this income group.

[c]Includes schools, hospitals and public office buildings.

Rand Report.

Figure 7



NOTE. The width of each bar corresponds to the percentage of total Mexico City households in each income category.

—Energy use, by income level: Mexico City, 1977

Rand Report

Figure 8

QUANTITY OF FUEL CONSUMED

SHARES OF VARIOUS FUELS IN HOUSEHOLD ENERGY USE
MEXICO CITY, 1977

Household Income Level (1970 pesos per month)	Shares of Fuels Consumed (percent of total household use[a])				
	Electricity[b]	Gas	Kerosene	Firewood & Coal	Total, All Fuels
0-1000 (16.5%)[c]	17.6	--	54.2	28.2	100
1001-2500 (43.5%)[c]	36.6	40.1	23.3	--	100
2501-5000 (22.0%)[c]	46.2	49.8	4.0	--	100
5001-10,000 (11.0%)[c]	51.0	46.7	2.3	--	100
Over 10,000 (7.0%)[c]	56.5	43.5	--	--	100
All levels	41.3	39.2	16.1	3.3	100

SOURCE: McGranahan and Taylor (1977).

[a] Includes cooking, space and water heating, appliance use, and lighting in residential households; does not include transportation uses.

[b] All electricity is based on primary energy measurement.

[c] Percentage of total households in this income group.

Rand Report.

also about the number of people living together (Tables VII-A and VII-D). In particular, because in some developing countries lacking indigenous energy supplies (Mexico and parts of Spain), the proportion of household income expended in cooking fuel and light can be in the order of 30 percent among the urban poor, so that price increases become a serious issue.

Table VII-C clearly shows that very few people live alone. Perhaps it is due to the high cost of living in the three big capitals (Paris, Madrid and Mexico City). In Mexico families still tend to be bigger than in the other two countries, both in the city and in the country. Sixty percent of the Mexicans live with four-eight people and 30 percent live with eight-12 people. In Spain, 55 percent live with four-eight people and 36 percent live with one-three people, and in France, 62 percent live with one-three people and 36 percent live with four-eight people. These results express each country's general trends and customs. Spain is slowly becoming more European in its customs, and adapting itself to a more stable (balanced), planned society. France's families are becoming smaller as the decade goes on, specially in the big cities where the cost of living is very high. Mexico, on the contrary, has one of the world's biggest population problems. The rate of growth in Mexico, according to the Global 2000 Report to the President* is the biggest in the world with a 3.1 average annual percent increase. It means that by the year 2000, Mexico City is projected to have 31.6 million people when in 1975 it had about 11 million people.

Firewood, charcoal, crop residues and animal dung account for virtually all of the energy used in many rural areas and for about 25 percent of total

*The Global 2000 Report to the President. Summary. Vol. 1. p. 9-12.

energy consumption in developing countries. Africa is most dependent, Asia somewhat less, and Latin America the least dependent on such sources. Consequently, developing countries have been consuming their wood supplies far more rapidly than they can be renewed, with grave environmental, social and economic consequences.

As a Mexican it was easier for me to obtain more reports about Mexico City. This is why Mexico City will be used in this case, to explain some of the reasons for energy use at different income levels. The Rand Study was based on some very interesting statistics about Mexico that cover the fuel consumption data by household in five income groups, with both energy use and income measured on a per household basis. Very large income-level variations were found in the use of fuels for transportation: (see Table V-A where most people own at least one car) - the richest families use more than thirty times as much energy (in BTUs) than the poorest. In domestic uses, such as heating, cooking, etc. the variation is much smaller, with fuel consumption doubling between the lowest and the highest income groups. All fuels used for transportation and public services in Mexico City are commercial fuels. Oil is virtually the sole source of energy in transportation, providing 95 percent of total energy. Electricity provides 85 percent of the energy used in public services.

In Mexico City, non-commercial fuels (wood and coal in this case) are burned only in the homes of the poorer inhabitants, and even they obtain most of their energy from other fuels. The share of kerosene in household energy use decreases markedly as income rises, while the share of electricity increases dramatically. The share of gas, near zero in the lowest income level, jumps to more than 40 percent at the second-lowest income level, but shows no clear trend thereafter as income rises. See Fig. 8

The amount and pattern of energy use in Mexico City are not representative of Mexico as a whole. The quantitative figures available for Mexico City are useful to explain the shed of urban fuel use in this developing country. A more general understanding of household energy consumption in Mexico must await further data.

Transportation accounts for 15-25 percent of total direct energy use in industrial countries, and for a similar or slightly higher proportion in middle income developing countries.[1] In many low income countries this sector accounts for only 10-20 percent of total energy consumption. Road transport (cars, trucks and buses) which accounts for 70-85 percent of the energy directly consumed in the transport sector, is by the largest consumer; rail and air transport typically consume about 3-5 percent and 5-10 percent respectively. Except in those few countries where railways are still fueled by coal or are electrified, mainly by hydropower, the transport sector depends almost entirely on petroleum, and in many countries it uses more than half the total petroleum products consumed.*

One way to reduce energy consumption, or slow down its rate of growth, is to shift traffic from less to more efficient carriers. Coastal shipping, river and rail systems are several times as energy efficient as road vehicles when used as heavily loaded bulk carriers, for example. For passenger transport, improvement of the public transport services would also help in diverting part of the traffic from private cars to more efficient bus or rail services. Electrification of rail or trolley bus services can make greater use of the indigenous resources used to generate power. Better spatial

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[1] Where indirect energy flows for the manufacture and maintenance of vehicles, and the construction, operation and maintenance of fixed transport infrastructure such as roads, airports, railway tracks, ports are included, transport may account for a further 10 percent or so of energy use.

*World Bank report. August, 1980. p. 56.

planning in industry and improvements in the telecommunications systems would also help to make transport more energy efficient.

Developing countries have a lower ratio of private cars to population or to GNP than the industrialized countries. They thus have the opportunity to avoid some of the problems that the latter are encountering in an era of high cost oil - not only heavy expenditures on oil itself but capital investment in highways. A mixture of policy measures is required including taxation of vehicle purchases and movements, improved traffic management and road maintenance, and improved mass transit, both within and between cities. Care must be taken not to discourage the use of bicycles, mopeds, jitneys and small buses, which substitute for the private car but which municipal authorities and the police tend to look upon as a nuisance.

Increasing the energy efficiency of vehicles may well be the most effective method of controlling energy consumption growth in the transport sector. Its potential is much greater than other approaches (see Fig. 9 - up to 20 percent savings can be expected), and it generally does not affect the quality of transport services or require behavioral changes on the part of the users or institutions. Pricing policy is probably the most flexible and effective method of energy demand management, but many governments are reluctant to use it vigorously because energy price increases invariably cause social and political opposition.

It is interesting to observe the results in Table V-A where the French respondents seem to be the ones who use public transportation more than the Mexicans or the Spanish, or at least they do not use their cars as much. Then, 66 percent French own a car whereas 79 percent of the Mexicans interviewed and 77 percent of the Spanish respondents interviewed owned at least one car. Forty four percent French do not own a car at all. In Table V-B,

Figure 9

DEVELOPING COUNTRIES: POTENTIAL FUEL SAVINGS IN TRANSPORT SECTOR, 1980s
(Savings as percentage of sector's energy consumption)

	Share of Sectoral Consumption	Savings From				
		Vehicle Efficiency	Regulatory Measures	Better Use	Demand Reduction	Cumulative
Trucks	35 - 45	6	2	10	5	23
Buses	8 - 12	2	(.)	5	(.)	7
Private cars	25 - 35	20	2	2	5	29
Shipping	5 - 10	2	5	5	(.)	12
Air	5 - 10	20	5	5	(.)	30
Rail	2 - 5	1	(.)	5	(.)	6

(.) Less than half the unit shown.

Source: World Bank staff estimates.

World Bank Publications. August, 1980. Energy in the Developing Countries.

83 percent of the total population interviewed who used the train were French. The same occurs for all the other public transport services (except for taxis, probably because they are quite expensive in Paris). French use public transport more than Spanish or Mexicans, according to the result of this survey. This shows us how an industrialized country that imports oil is conscious of how much it is spent in petroleum, and thus, they are really trying to save it, or to use it in the best way. Mexico is a non-OPEC developing nation that as an exporter (mainly of oil in this case) has not gotten to an energy crisis yet, like the other nations have. Spain has an energy problem but the problem is that its transport system is still not very well developed and not very efficient throughout the whole country. These points are reflected in the answers of Tables V-A and V-B.

In order to simplify the understanding of each country's energy profile and energy priorities in the near future, I will proceed by taking each energy source separately and explain its role within each country.

The Nuclear Option -

Nuclear power development could offer some freedom from dependence on imported oil because of its apparent security from interruption. For most developing countries (Spain and Mexico included), except for a few of the largest most technically advanced nations (France), these advantages are largely illusory because of its very high capital cost, dependence on imported technology, international agreements and restrictions on fuel supply, and the fact that the smallest reactor is large in relation to the system size in most of the countries.

In general, there is political and emotional opposition to nuclear energy mainly because of its problems of radioactive waste disposal, security and

safety. If one considers the number of reactors that will be required for this technology to make a real contribution to the total world energy supply by the turn of the century, these points are valid. Consequently, while forecasts of nuclear power capacity still show large increases up to 1985, most of these increases originate from plans made some years back for plants which are now under construction. Figure 10* presents the total capacity expected to come on line between 1978 and 1990 in several developing countries.

Nuclear energy is the most capital-intensive source of power, requiring 1.5 to 2.5 times as much capital as comparable oil- or coal- fired electric power plants, but its fuel cost is half to one-sixth as much. Nuclear fuel costs are a function of the price and availability of uranium and plutonium and the cost of processing these into fuel elements. The rapid growth in the use of uranium is likely to exert upward pressure on nuclear fuel price unless new uranium ore discoveries are made, or new nuclear technologies, such as breeder reactors, become technically and economically feasible as well as politically acceptable.

As figure 11 indicates, apart from the industrialized nations, only the countries mentioned there could economically utilize a 600 MW commercially available nuclear reactor. Mexico has only two reactors exclusively built for electric power that are under construction, and no reactors planned for the next few years. In 1978, seven percent of the world's electricity was supplied by nuclear power stations located mainly in Europe, Japan, North America and the USSR. Less than two percent of the electricity in the developing countries is presently supplied by nuclear energy.

Table VI-A indicates the sample's knowledge of different sources of energy. After explaining a bit about what the nuclear option could be, it is

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* World Bank report. #350, August, 1979. p. 74.

Figure 10

INSTALLED GENERATING CAPACITY IN THE DEVELOPING COUNTRIES
(millions of kilowatts)

Type	1976	1980	1985	1990	1977-1990 Additions	
Hydro	70.4	101.0	149.5	205.8	135.4	(33.3%)
Geothermal	0.1	0.4	1.4	2.3	2.2	(0.5%)
Nuclear	1.2	4.3	22.1	62.4	61.2	(15.1%)
Thermal	101.6	149.6	217.0	308.8	207.2	(51.1%)
Total	173.3	255.3	390.0	579.3	406.0	(100.0%)

World Bank Publications. # 350. p. 68

Figure 11

DEVELOPING COUNTRIES: REACTORS OPERATING, UNDER CONSTRUCTION AND PLANNED AS OF MAY 1978

	Operating Reactors		Under Construction		Reactors Planned		Total	
	No.	NEP 1/	No.	NEP 1/	No.	NEP 1/	No.	NEP 2/
Argentina	1	0.3	1	0.6	1	0.6	3	1.5
Brazil	-	-	3	3.1	-	-	3	3.1
India	3	0.6	5	1.1	-	-	8	1.7
Iran	-	-	4	4.2	4	4.8	8	9.0
Israel	-	-	-	-	1	0.6	1	0.6
Korea, Republic of	1	0.6	2	1.2	2	1.8	5	3.6
Mexico	-	-	2	1.3	-	-	2	1.3
Pakistan	1	0.1	1	0.6	-	-	2	0.7
Philippines	-	-	1	0.4	2	1.4	3	1.8
Thailand	-	-	-	-	1	0.6	1	0.6
Turkey	-	-	-	-	1	0.6	1	0.6
TOTAL DEVELOPING	6	1.6	19	12.5	12	10.4	37	24.5
TOTAL INCL. CPEs.	215	102.4	231	209.2	141	135.3	587	446.9

Source: International Atomic Energy Agency.

1/ Net electrical power in GW (thousand MW).

2/ Does not take possible closures into account.

World Bank Publications. # 350. p. 75

clear, that only 16 percent of the Mexicans interviewed knew about nuclear power generation; in Spain, only 22 percent and in France, 77 percent. This is probably true because of each country's environment and their particular policy on nuclear energy. Of these three countries, France is "going nuclear" more than the other two. In the "Energy Policy of France" published by the Ministere de l'Industrie Francaise, it is explained that in view of reasonably foreseeable expectations for types of energies, France has no viable alternative to nuclear power other than economic recession and dependence: "nuclear energy in France remains today as the most appropriate solution to the electrical power production and yields KWh that are at least 20 percent below the price of standard coal and fuel-oil thermal systems."

Installed nuclear capacity in 1985 will total 40,000 MWe and will supply around 55 percent of France's power demand. That output will be equal to one fifth of France's energy needs and will represent a savings of 43M (tons of oil equivalent). This figure taken from the Energy Policy of France is indeed very close to what the French respondents estimated in Table VIII-D where they indicated that nuclear power has a 40 percent importance and probability of success in France.

The French government intends to continue its work in this field to provide information and organize consultations at all levels. The number of debates organized at local, departmental and regional levels, and changes in regulatory procedures providing greater public access, prove that the government is concerned with informing the officials and populations involved. The creation of the nuclear-electric power information council and its initial work are yet another confirmation of this fundamental direction.

Promotion of the use of natural resources and mainly production of electrical power from nuclear sources will reduce France's energy dependence

from 75 percent to around 65 percent in 1985. Also, diversification of supply sources, coupled with energy conservation and development of national resources, is a main axis of French energy policy.

In the World Bank's Summary of International Solar Programs from the Renewable Resources Energy Department's report (1980), Spain's energy supply is explained briefly as follows: Spain is largely dependent on foreign sources for its energy supply, with about 80 percent of the total imported. Coal, oil and hydroelectric resources are the major sources of energy at present and contribute over 80 percent of the total energy budget, which amounts to 87 Mtec (million tons of equivalent coal). The percentage of the energy sources in 1974 and the corresponding projected figures for 1985 are shown below:

	1974	1985
	(percent of overall energy budget)	
Coal	14.90	13.7
Hydroelectric	12.37	8.2
Oil	68.91	43.7
Natural Gas	1.28	11
Nuclear	2.54	23.4

The expected dependence on foreign energy sources in 1985 will be reduced to 70 percent, still a large figure. According to the PEN-78 (Plan Energetico Nacional), Spain will turn "nuclear" by 1987. The government believes that nuclear energy will be the only alternative that can help the energy problem in Spain even if there are many people (including the Friends of the Earth group) who oppose such change (see Figure 24). The energy balance in 1977 (see Figure 25) clearly indicates that Spain depends on petroleum imports very much (97.8%), followed by coal. Hydraulic energy is a very important source in Spain as well.

Figure 24

	1978		Alternativa 1987		PEN 1987	
	Mtec	%	Mtec	%	Mtec	%
Nuclear	2,4	2,4	—	—	21,5	14,8
Petróleo	67,5	66,8	69,7	50,0	78,7	54,3
Gas	1,8	1,8	16,8	12,0	7,7	5,3
Carbón	15,3	15,1	28,0	20,0	23,5	16,2
Hidroelectricidad	14,0	13,9	18,5	13,0	13,6	9,4
Solar directo	—	—	3,6	2,6	—	—
Geotermia	—	—	1,0	0,7	—	—
Biomasa	—	—	1,6	1,0	—	—
Eólica	—	—	0,8	0,6	—	—
TOTAL	101,0	100,0	140,0	100,0	145,0	100,0

Modelo Energético de Tránsito. Madrid, 1980. p.18

Figure 25

BALANCE ENERGETICO 1977

	Mtec [illegible]	% E.P.	Producción Nacional	Producción Importada
Energía nuclear .	2,0	2,0	100,0 %	—
Energía hidráulica	14,0	14,3	100,0 %	—
Gas natural	1,7	1,7	—	100,0 %
Carbón	15,2	15,5	78,7 %	21,3 %
Petróleo	65,2	66,5	2,2 %	97,8 %
TOTAL	98,1	100,0	29,9 %	70,1 %

Modelo Energético de Tránsito. Madrid, 1980. p.19

In Table VIII-D, Mexican respondents estimated that in their country nuclear energy will supply about 10 percent of the total energy need and 30 percent of the world's energy need. The Spanish respondents estimated that their country will depend on nuclear by 40 percent, whereas 50 percent for the world's nuclear energy supply. The French estimated their country will depend on nuclear by 40 percent and the world by 35 percent. These results indicate the environment in each country, or reflects people's reactions toward their government's energy policies.

SERI (Solar Energy Research Institute. Golden, CO) wrote a report on "Energy in Mexico" (April, 1980) assuring that nuclear power will not be used in the immediate future. Mexican planning concentrates instead on the development of the abundant petroleum and gas resources, although exploitation and exploration will continue for coal, hydro and geothermal sources will be exploited as well. The energy policy objectives include: the diversification of primary energy sources in order to decrease dependency on oil and gas; promotion of more efficient energy utilization; coordination of planning in the energy sector; development of capital goods associated with the energy sector; and promotion of energy research and development activities.

The Mexican respondents estimated that only 10 percent of their country's energy supply will be obtained by nuclear power systems and 30 percent for the world's energy needs. (see Table VIII-D) This is logical, because of all the recent petroleum discoveries which are proven reserves up to 40 billion barrels and probable reserves up to 200 billion barrels. Mexico currently produces 1.8 million bbl/day and exports one third of that total. By the end of 1980, one million of the 2.25 - 2.50 million bbl/day will be exported. Petroleum is the fastest growing sector of the economy, and Mexico hopes to invest petroleum export revenues into an industrial development program. In

1978 the federal government allotted 60 percent of the budget for all Mexican industry to PEMEX (Petroleos Mexicanos), the national oil company.*

The Geothermal Option -

Geothermal resources consist of underground aquiferus containing superheated water and steam at temperatures up to 250^{o}C, which are exploited by means of wells of about 200 - 4000 feet deep. They are used for electric power generation, industrial process heat and space heating. It can also be used for domestic space heating and hot water supply.

Geothermal power resembles hydropower in its capital structure in that it has a relatively high initial capital cost followed by low operating costs, and no fuel requirements. It has a further advantage that it can be constructed in increments as power demand increases. The low steam pressures ingeothermal fields mean that electricity is generated from a large number of relatively high system reliability for a stated level of output. Problems associated with development are the corrosive nature of the steam, the high noise level associated with wet steam fields, and the need to dispose of very large quantities of hot mineralized water from wet steam fields. Development problems with dry system fields are fewer, but so far the only dry steam fields which have been developed are Larderello in Italy and the Geysers in California (USA). The cost of installed geothermal electric generating capacity is estimated to be about \$1,700/kWh.[1]

In Table VI-A people in Mexico did not know anything about geothermal energy. In Spain, 13 percent did know something (which is 33 percent of the total population interviewed - Table VI-B) and in France 27 percent (which is

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* Energy in Mexico. SERI. April, 1980.
1 World Bank Publications. #350. p. 50.

67 percent of the total population interviewed).

Mexico has 120 geothermal areas. By 1999 geothermal is expected to provide up to 70 percent of all Mexican electric generating capacity. The Cerro Prieto plant, built in 1973, now generates about 75 MW from 50 wells, enough to power the cities of Mexicali and Tijuana (North of Mexico) during periods of low demand.*

France hopes to obtain only about one to three percent of its total energy by 1985 from geothermal sources. This is due to the country's geological structure. France's geothermal resources are provided by aquiferus contained mainly in sedimentary basins, and by numerous hot springs. A total of 500,000 housing units are scheduled by 1990 to be equipped with geothermal heating installations. The eight installations that are already completed now provide 25,000 toe annual energy savings.[1]

Most efforts to develop France's geothermal energy potential are concentrated on low-temperature geothermal heat. This involves exploiting the hot water trapped in deep underground geological formations and using the heat thus obtained in circuits of surface geothermal installations.

In Spain, the government will invest very little in any kind of perforation. They expect geothermal energy to supply up to five percent of the total energy production in Spain.[2]

The Eolian Option -

There is a great deal of experience in the use of wind power plants for generating electricity or mechanical pumping power. Systems range from do-it-yourself installations to utility-sized applications. Systems are in use

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*Energy in Mexico. SERI. April, 1980.
[1]Ministere de l'Industrie. 1979 French Energy Policy
[2]Modelo Energetico de Transito. pp. 80-85.

today and are being installed in remote areas where power from the central utility system is not available or not too expensive, or where operation of engine-generators is impractical. Most of the commercially available wind generators have maximum outputs in the 0.1 to 15 kw range. The present world-wide market for small wind generators is estimated to be only about \$3 - \$6 million, but it is expected to grow substantially as the cost of conventional energy sources increases and the technical economic performance of wind turbine systems is improved.

In Table VI-A, the Mexicans respondents indicate that they do not know much about eolian energy. Thirteen percent of the Spanish ones know about it, which represents a 33 percent of the total population interviewed (Table VI-B). But, 27 percent of the French do know about eolian energy, which is a 67 percent of the total population interviewed. Once more, the answers probably reflect the country's attitude versus this specific energy source.

Of the three countries, Spain seems to be the only one who has available information on how eolian energy is presently being used in the country (or how it will be used in the near future). Spain will invest in those coastal zones that have some strong-wind areas, such as the Gibraltar, Finistere, Levante and La Mancha. By 1987, 0.8 Mtec will be used to generate electricity: 500 generators of 2MW in a 150 km^2 area (almost unpopulated areas) will be installed in order to increase production to 3.4 Mtec by 2000.

The Biomass Option -

Developing countries (more so than developed ones) depend on traditional fuels such as firewood, crop residues, and animal dung to meet between 50 percent to 90 percent of their domestic energy needs, principally for cooking. As the population in these countries increases, supplies of these fuels are

becoming inadequate in many cases. The pressure of demand for firewood has resulted in severe deforestation, especially in countries with a semi-arid climate where forest regeneration is slow. Often deforestation results in the loss of topsoil, and this, combined with overgrazing by browsing animals such as sheep and goats, prevents any regrowth. The result is an increasing deficit of fuels available to the poorer sections of the population for cooking.

In many developing countries (Mexico and some areas in Spain included) where the domestic sector is supplied by traditional fuels, obtaining such materials (fuels) takes up an increasing proportion of the domestic budget, either in cash or in the time expended in gathering fuel. In urban areas where the transition has been made to commercial fuels, the price of these has become a sensitive political issue.

The so-called "firewood crisis," relating to the growing scarcity of traditional fuels used in the domestic sector, is a serious issue which calls for consideration in planning and policy decisions. All too often traditional energy sources are neglected by governments because their use, generally, is not recorded and reliable statistics are therefore not available.

The commercial development of biomass could help to reduce the need for oil imports in countries which are short of capital and high technology. Some advantages for the development of organic resources are that supplies are localized and decentralized, and they can be developed at low cost without highly sophisticated technology. This enables developing countries to choose schemes which are technologically most appropriate to their own needs. Additionally, their use provides employment in many rural areas, wood fuels still have a large contribution to make to energy supply, and a program fully utilizing this resource would also increase a developing country's

energy self-reliance.

Where cattle dung, piggery waste and crop residues are used as the main supply of fuel rather than as a fertilizer, it would be possible to ferment waste anaerobically (without air or oxygen) in a biogas plant. The gas produced is 60 percent methane, which can be used for cooking and lighting, and the remaining sludge can be used as a fertilizer. In this way organic waste can be substituted for firewood without subsequent ecological damage. (India and Kenya have biogas programmes because deforestation is now a critical problem in both countries).

Organic matter can also be converted to alcohol. Sugarcane and cassava can readily be fermented to yield ethanol, and in Brazil, sugar derived ethanol is already mixed with gasoline to give the motor fuel known as "gasohol". Without engine modifications, the proportion of ethanol can be up to 20 percent. With some engine modifications, ethanol can be used without gasoline (already undertaken by car producers in Brazil).

Table VI-A clearly indicates that the respondents of Mexico and Spain do not know anything about biomass, and in France only five percent of the French respondents (interviewed in 1980) knew about it. This indicates that the people generally are more acquainted with whatever energy policy their country follows. In Chapter VIII of the "Energy Policy of France", the Ministere de l'Industrie concludes that photosynthetic and bioconversion of solar energy represents one of the keystones of France's policy for development of renewable energy sources in future years. Large quantities of inadequately exploited agricultural and forestry residues, e.g. wood, can be immediately used as energy sources. Numerous processes are available for converting collected materials in boilers, gasification, pyrolysis, hydrlysis and methane fermentation. In France, in either recycled or byproduct form,

wood is now a profitable exploitable domestic energy resource (13 million hectares of wooded area). In 1976, the total consumption of fuel wood for heating was 2 Mtoe, (1.3 Mtoe for industry and 0.7 for residential sector). Today, for every 100 trees cut down for consumption, 30 become finished products and 70 are rejected as scrap. Twenty-two of the latter are further exploited, only 15 are converted into energy and 33 are disposed of as unusable.

However, since the cubic meter (m^3) - stere - of wood has a current market value of 85 to 115 F francs when transported a distance of 20 km or less, wood burned in oil/wood - fired boilers is competitive in comparison with fuel oil, for instance.

The established goal is to increase total wood consumption to four Mtoe (Metric tons of oil equivalent) by 1990. Accordingly, several activities have been initiated in various regions to encourage the use of wood as an energy source by individual consumers.

In Spain, the photosynthetic potential is of 25 g/m^2 per day. Even if biomass has not been seriously considered before, the new policy according to PEN (Plan Energetico Nacional - National Energy Plan) -- 1980, biomass might help Spain in becoming more energetically independent from imported oil. In the methanol form (as fuel for transportation) it will be the alternative, by 1987, to substitute fuel oil. Hence, reforestation in a great scale and use of organic residues among other measures, should be the immediate objective in the new energy politics. Investments in new technology will be seriously taken into account by the government.

In Mexico, new studies in this field will be considered until 1981-1982.

The Fossil Option -

Only the most important and significant fossil fuels will be mentioned in this discussion. They will be included in this study because the present world energy situation is due to oil, its price changes and its production. Hence, it cannot be excluded from this study.

OIL -

Crude oil is a mixture of liquid substances composed mainly of carbon and hydrogen, which when distilled are separated into fractions of varying boiling ranges, from naphtha at the light end through kerosene, for making gasoline, and diesel fuels are obtained from the gas oil fraction. Crude oils vary widely in their content of the various boiling point fractions. Since the light fractions usually command the highest price, light crude commands a market premium over heavy crudes. Impurities such as sulphur and certain heavy metals are usually concentrated in the residual fuel. High concentrations of these reduce its commercial value.

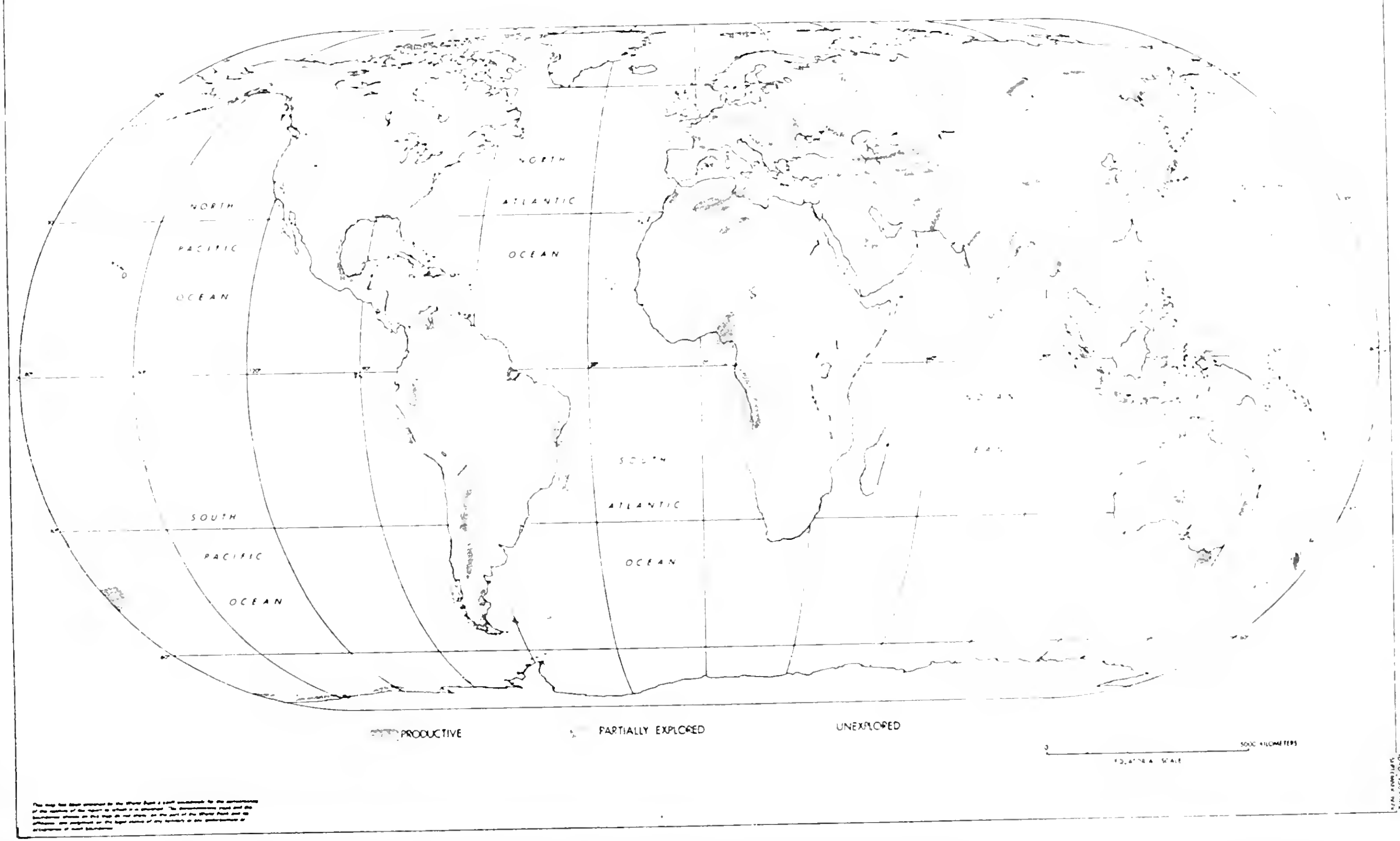
Since the 1950s oil has been the dominant source of commercial energy in the world. Despite the renewed emphasis on the development of other sources of energy, including coal and nuclear, oil will continue to supply 35-40 percent of the world's commercial energy demand during the rest of the 1980's, and a much higher share of the demand for commercial energy in oil importing developing countries (such as Spain).

Over 75 percent of the world's proven oil reserves of about 640 billion barrels (bb) are located in the Middle East, North America and the centrally planned economies, and these areas account for an equal share (73 percent) of world oil production.* The urgency of discovering new oil resources is

*World Bank Publications. August, 1980. p. 13-15.

MAP #1

PETROLEUM BASINS OF THE WORLD



underlined by the fact that world oil consumption is now growing almost as fast as additional reserves are being developed.

In 1979, after allowing for a record high production level of 22.8 bb, the world's proven oil reserves increased by 15 million barrels. This increase was made possible only by the discovery and development of substantial additional reserves in Mexico.*

Developing countries have a large potential for oil and gas production. At present these nations (including OPEC countries) produce onethird of primary energy production and 60 percent of world crude oil production. Non-OPEC developing countries produce about five percent of world petroleum and also produce about five percent of internationally traded crude oil, although this proportion is increasing with the re-emergence of Mexico as a major oil exporter.

NATURAL GAS -

Natural gas may be almost pure methane, but also, it may occur mixed with noncombustible gases such as nitrogen and carbon dioxide, which may be less present in such large proportions as to render the gas commercially valueless. Hydrogen sulphide is a poisonous contaminant which is often present and must be removed before natural gas can be marketed. Natural gas can occur alone in a reservoir or in solution in crude oil with which it is produced. "Wet gas" contain higher hydrocarbons such as propane and butane which can be separated and liquefied under pressure into LPG (Liquefied Petroleum Gases). Raw gas must be dehydrated and stripped of contaminants (hydrogen sulphide and carbon dioxide), and LPGs must be removed, before it

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* World Bank Publications. August, 1980. p. 13-15.

can be transported by pipeline. Associated gas may simply be burned as waste or compressed, and put in a pipeline for transport to market. Ethane must also be recovered from natural gas for use as a petro-chemical feedstock where a market exists. Oil and gas are found in sedimentary basins. Map I shows the approximate area of the known sedimentary basins.

The physical characteristics of gas, particularly the difficulties of transporting it, limited its share in the growth on international energy trade. Until techniques were developed in the 1960s for ocean transport of liquefied natural gas, international trade depended on land pipelines. Gas development for domestic use in some developing countries has also been somehow limited because markets have rarely been large enough and concentrated to absorb the high cost of pipelines and distribution facilities and hence make gas more competitive with oil products (fuel oil).

According to the World Bank estimate of August, 1980, "Energy in the World," world natural gas reserves are about 456 billion barrels of oil equivalent, which is about 72 percent of proven oil reserves and 15 percent of proven coal reserves. More than 75 percent of the gas reserves are in North America, the Middle East and centrally planned economies, including China.

Natural gas is an underutilized resource in developing countries. At the present time a very large proportion of the associated gas produced with crude oil is burned as waste (flared). The loss of energy which results is enormous, estimated to be equivalent to nine million barrels of crude oil per day in 1977.* The utilization of natural gas in developing countries, especially, is expected to increase fairly rapidly in the next two decades.

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* World Bank, August, 1980. p. 31.

COAL -

Coal is a solid fuel consisting predominantly of carbon but containing in most cases substantial quantities of volatile matter, moisture, and mineral ash, and a usually minor percentage of sulphur. Coal occurs in layers (beds or seams). The layers may be only a few inches thick, up to 20-30 feet or even more in some cases. The range for mineable coal is usually between 2-10 feet thick. Coals are generally classified by their heating value (calorific value) expressed in British Thermal Units per pound (BTU/1b) or kilocalories per kilogram (kcal/kg). The principal use for coal is as a boiler fuel, with the exception of metallurgical grade cooking coal which is used as a chemical reagent in the smelting of iron ore. Coal can also be used as a domestic fuel, particularly if it is processed to make smokeless fuel.

The World Energy Conference in 1977 showed economically technically recoverable coal reserves in the world to be of 636 billion metric tons, of which only 10 percent is located in the developing countries. Total known coal reserves in the developing countries are reported to be about 230 billion metric tons. Coal production costs vary over a wide range, but open-cast mining is invariably much cheaper than underground mining. Mining costs on a worldwide basis in 1977 averaged \$10-15 per ton for open-cast mines, and \$20-30 per ton for underground mines. For a good grade of steam coal, this would compare with a cost of \$14-20 per ton of fuel oil equivalent for open cast coal and \$27-40 per ton of fuel oil equivalent for coal underground mines. Cost of coal transport by rail may be of the order of \$0.02-0.03 per ton mile. Even allowing for the higher cost of transporting and using coal as compared with fuel oil, and the fact that many coal deposits in developing

countries are of inferior grade, such a price differential would appear to give ample incentive for accelerated development of indigeneous coal resources in developing countries.

Certain types of bituminous coal can be made into coke by heating it in the absence of air (being carbonized). Coke is a hard, brittle, porous substance widely used in the smelting of iron ore, and metallurgical grade coking coal remained an export commodity even through the era of cheap oil prices. Manpower requirements for coal mining are higher than for oil production, and underground mining is considerably more labor intensive than open-pit mining.

Other fossil options that are less known by the people in general are oil shale, synthetic fuels, tar sands, peat and uranium. They will not be included in this discussion though they could have a significant role in some nation's energy production.

"Energy in Mexico"* reports that Mexico has proven reserves of oil of up to 40 billion barrels and probable reserves of 200 billion barrels (bbl). Mexico currently produces 1.8 million bbl per day and exports one third of that total. By the end of 1980, one million of the 2.25-2.50 million bbl per day will be exported. Petroleum is the fastest growing sector of the economy, and Mexico hopes to invest petroleum export revenues into an industrial development program. In 1978, the federal government alloted 60 percent of the budget for all Mexican industry to PEMEX, the national oil company.

In Table VI-A, 62 percent of the Mexican respondents knew about the fossil option category. This is probably because of the importance that oil has in the country nowadays. In Table VIII-A Mexicans indicated that electri-

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*SERI. April, 1980. D. Hawkins.

cal power plants are more efficient when they use nuclear or fuel-oil as energy source. For them coal plants have only a 15 percent efficiency. In Table VIII-D fossil fuels (mainly oil) will represent up to 40 percent of the total energy source in their country and 30 percent for the world. This last figure is only five percent less than the 35 percent estimate given by the World Bank, which means that the Mexicans had a very good idea of the importance of oil in the world today.

Mexico has considerable natural gas reserves as well. Daily production of 65.5 million cubic meters (m^3) of associated gas and 18 million m^3 of unassociated gas represents a 34 percent increase over the 1978 figures. Domestic consumption has increased substantially due to government subsidies and coal-to-gas conversion programs for large utilities. The federal government has decided to stimulate domestic consumption of natural gas so that hydrocarbon exports can be made in the form of fuel oil.

Uranium reserves of 136,365 tons are the largest in Latin America. Mexico plans to develop nuclear power to aid some of the future energy needs. The Laguna Verde facility is now under construction and will begin to operate in 1982.

An interesting example of an energy balance for a developing country is that published by the Mexican Government in the monthly bulletin "Energeticos" from which figure 12 is derived.* It explains that one of the practical problems encountered in striking an energy balance is that of reducing all energy sources to a common dimension. This is usually expressed in heat units, but it may also be expressed as tons of coal equivalent or tons of oil equivalent, based in the relative calorific values of these fuels.

* World Bank publication #350, p. 84

Figure 12

MEXICO: ENERGY BALANCE, 1977
(millions of barrels of oil equivalent)

Energy Source	Industry	Transport	Residential	Agri-cultural	Other	Non-energy	Petroleum sector	Electrical sector	Total
Coal	25.0							0.3	25.3
Fuel oil	41.6							45.9	87.5
Natural gas	45.6		3.6				38.1	11.0	98.3
Electricity	15.4		4.9	1.8	5.5				27.6
Gasoline		79.3							79.3
Diesel		63.6						6.2	69.8
Aviation fuel		7.3							7.3
Kerosene			12.2	2.0					14.2
Undifferentiated Petroleum products						17.8	28.3		46.1
Liquefied Petroleum gas			19.7						19.7
Hydro-geothermal								44.9	44.9
Electrical power distributed								(27.6)	(27.6)
Total	127.6	150.2	40.4	3.8	5.5	17.8	66.4	82.1	493.8

Source: Adapted from Comision de Energeticos.

World Bank Publications. # 350. p. 84

In the case of coal, SERI reports that Mexico has three states that have approximately 650 megatons of economically recoverable resources. Four new mines will be opened and other renovated and enlarged over the next three years at a cost of five billion dollars. Coal, which currently supplies 6.3 percent of Mexico's energy, is projected to supply up to 12 percent by the year 2000.

Spain depends very much on oil exports but is hoping to become self-sufficient by the year 1990 according to the "Modelo Energetico de Transito"*. Oil reserves are estimated to be up to 30 million metric tons with a rate of production of about one million tons per year until 1990. But the problem still will remain because of the rapid and continuous increase in oil demand which is now faster than production. Some fuel-oil will be saved when the new nuclear power plants start functioning at full capacity and maybe save about 2.2 million metric tons of oil.

The PEN-78 hopes that by 1987 the total oil consumption will be of 70 Mtoe (Metric tons of oil equivalent), compared to the 67.5 Mtoe of 1978 if the same waste rate continues. But it could even go down to 60 Mtoe if a policy of real conservation is followed throughout Spain. PEN-78's goal is to justify Spain's nuclearization process by reducing the country's dependency on oil. (see fig. 26)

The oil will be substituted by two Mtoe of uranium which means that only 14 percent of the total oil imports will be saved. Figure 13 shows how Spain projects the difficult task of increasing oil consumption instead of reducing it.[1] Then PEN-78 presents another alternative by increasing natural gas consumption from a 5.3 percent in 1978 to a 12 percent by 1987. But in order to

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* Madrid, 1979. Coleccion Amigos de la Tierra #3. p. 32

[1] Modelo Energetico de Transito. PEN-78. p. 37.

Figure 26

PREVISIONES PRODUCCION ENERGIA ELECTRICA EN EL PEN

	1977			1982			1987		
	Mtec	% E. P.	% E. E.	Mtec.	% E. P.	% E. E.	Mtec	% E. P.	% E. E.
Hidráulica	14,0	14,4	42,9	12,2	10,2	28,7	13,6	9,4	23,8
Nuclear	2,0	2,0	6,1	11,7	9,8	27,5	21,5	14,8	37,7
Térmica	16,4	16,7	50,3	18,0	15,0	42,3	21,4	14,8	32,9
— Carbón	7,1	7,2	21,8	11,4	9,5	26,8	15,3	10,6	26,8
— Fuel	9,3	9,5	28,5	6,6	5,5	15,5	6,1	4,2	6,1
Autoproducción	0,2	0,2	0,6	0,6	0,5	1,5	0,6	0,4	1,0
TOTALES	32,6	33,2	100,0	42,5	35,5	100,0	57,1	39,4	100,0

Modelo Energético de Tránsito. Madrid, 1980. p. 59

Figure 13

PREVISIONES DE CONSUMO DE PETROLEO
(PEN-78)

	1977 Mtec	%	Prev. 1987 Mtec	%
Consumos propios	3,2	4,9	5,0	6,3
Combustibles ligeros:				
— gasolina	7,6	11,6	11,1	14,1
— gasóleos	13,8	21,0	18,0	22,9
— otros combustibles ligeros	8,2	12,4	8,6	10,9
Combustibles pesados				
— fuel térmico	8,1	12,3	6,1	7,8
— otros fueles	18,3	27,9	20,6	26,2
No energéticos:				
— petroquímica	3,5	5,3	5,3	6,7
— asfaltos y otros	3,0	4,6	4,0	5,1
TOTAL	65,7	100,0	78,7	100,0

Modelo Energetico de Transito. Madrid. p. 37

do this Spain might need to import natural gas from Algers, unless new natural gas sources are found in Spain soon. Their intentions are to follow what other EEC members have achieved, a five-20 percent consumption of natural gas that will supply mainly electricity. But Spain's strongest energy sources (compared to EEC) are still oil and nuclear (see Fig. 27)

In Table VI-A, 55 percent of the Spanish respondents knew enough about fossil fuels, especially about oil and natural gas. In Table VIII-D they estimated that their country will only depend on fossil fuels (basically oil) about 30 percent and the world 24 percent. This clearly demonstrates what the Spanish environment is emphasizing upon nowadays: the nuclear and hydroelectric options are the priorities rather than the other energy options.

France's petroleum is essentially provided by two types of supply chains: the French group refining subsidiaries (Total and Elf) and those major international groups (Esso, BP, Mobil, Shell) to which two European companies have been recently added (Fina, Agip). The Ministere de l'Industrie reported in its Energy Policy in France, how much French depend on imported oil (see Figure 14), specially on Saudi Arabia's who supplied up to 35 percent of France's oil in 1978, followed by Iran (nine percent), Nigeria and Abu Dhabi (six percent each). The import structure has been marked over the last few years by a drop in the relative share of lightweight crudes near at hand, which of course is the consequence of the imported heavy fuel-oils that have taken on the French and North American markets (Figure 15).

Because of the 1973-74 crisis and the subsequent five times increase in the price of crude petroleum, the French government took legal and regulatory measures (just like many other European countries) aimed at conserving energy and favored a diversification of energy sources (nuclear power, natural gas, alternative energies). The volume of natural gas produced in France in 1977

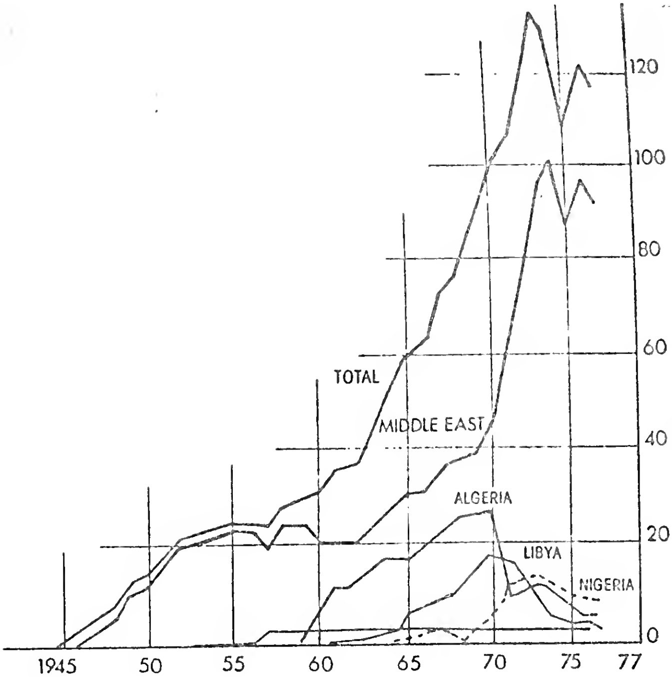
Figure 27

APORTACION DIVERSAS FUENTES A LA PRODUCCION DE ENERGIA

	1987 Previsión PEN tanto por ciento	1985 Prev. CEE tanto por ciento
Carbón	16,2	17,2
Petróleo	54,2	50,7
Gas natural .	5,3	18,5
Nuclear	14,8	10,9
Hidráulica ..	9,4	2,7

Modelo Energético de Tránsito. Madrid, 1980. p.40

Figure 14



. When broken down by source, it appears that Saudi Arabia was the leading supplier of France in 1978 (35%), followed by Irak (18%), Iran (9%), Nigeria and Abu Dhabi (6% each).

. The import structure has been marked over the last few years by a drop in the relative share of lightweight crudes near at hand (cf. table and graph), which is of course the consequence of the importance heavy fuel-oils have taken on in our market but also and above all the result of the higher value given to these types of crudes on other markets, especially those of North America, whereas less-specific crudes are required for the economic supply of French demand.

French Energy Policy. Ministère de l'Industrie. Paris, 1979.

Figure 15

CRUDE OIL IMPORTS

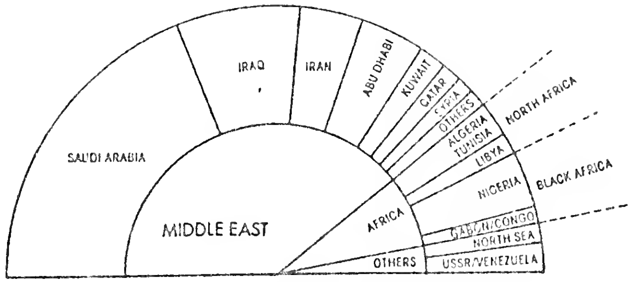
(French requirements)
(millions of tonnes)

Year 1978	French companies	International companies	All
IRAN	1.6	8.8	10.4
IRAQ	12.6	7.9	20.5
KUWAIT	-	2.4	2.4
SAUDI ARABIA	22.9	16.6	39.5
ABU DHABI	5.2	1.8	7.0
DUBAI	2.5	0.1	2.6
QATAR	-	4.2	4.2
OMAN	-	0.2	0.2
SYRIA	-	2.3	2.3
MIDDLE EAST TOTAL	44.9	44.2	89.1
EGYPT	-	0.4	0.4
LIBYA	1.3	1.9	3.2
TUNISIA	0.2	-	0.2
ALGERIA	3.2	0.1	3.3
NIGERIA	2.1	5.1	7.2
CAMEROUN	0.1	-	0.1
GABON	0.4	0.7	1.1
CONGO	0.1	-	0.1
USSR	1.4	1.6	3.0
NORWAY	1.4	0.2	1.6
GREAT BRITAIN	-	1.6	1.6
VENEZUELA	-	0.8	0.8
INDONESIA	-	0.4	0.4
TOTAL OTHERS	10.3	12.6	23.0
OVERALL TOTAL	55.2	56.8	112.1

The total inflow of imports was provided fairly equally by French groups on the one hand and by foreign groups on the other.

French Energy Policy. Ministère de l'Industrie. Paris, 1979. p.22

Figure 15 *



EVOLUTION OF STRUCTURE OF FRENCH OIL IMPORTS

In 1978, by origin, Saudi Arabia was France's leading crude oil supplier followed by Iraq, Iran, Nigeria and Abu Dhabi. On the other hand this evolution resulted in a reduction of the share of light crudes from North Africa.

French Energy Policy. Ministère de l'Industrie. Paris, 1979. p.24
*In a graph.

amounted to 8.3 billion KWh and the imports of gas were 162.8 billion KWh. These figures show how much natural gas consumption has been increasing in France during the last few years.

Thus, one of France's intentions is to increase its use of gas in all consumption sectors (see Fig. 16). Total gas sales rose 3.7 percent in 1977. Natural gas sales represented 74.4 percent of the total gas sales. In the three years 1975, 1976 and 1977, the number of natural gas public service systems increased from 420 to 450; correlatively the number not supplying natural gas declined from 408 to 360. So the tonnage of oil products used for production of manufactured gas by the gas industry is falling: 41,600 tons as against 56,500 in 1976.

For the French people gas is really a non-polluting form of energy which lends itself to energy conservation, especially in household heating, in which it is particularly well suited to individual expedients enabling 20 to 25 percent to be saved compared to other heating needs; gas is also a fuel and raw material in high industrial demand. The increasing use of gas to satisfy French energy needs should contribute to the diversification and hence to the security of the nation's energy supply -- in 1985 it should cover 16 percent of French energy requirements.

The share of coal in France's energy supplies will remain stable. This objective means a continuing exploration of national resources and calling of some internationally available supplies taking into consideration the competitiveness of coal with fuel oil. Over the last few years, French consumption of coal has stayed relatively stable, conforming to the general orientation of French coal policy (see Fig. 17).

It is very probable that the French respondents knew more than the Mexicans or Spanish about fossil fuels because of the fact that there is

Figure 16

GAS* Consumption per sector (MTOE)

	1960	1965	1970	1973	1974	1975	1976	1977	1978	1980	1985
Steel	0.7	0.7	1.1	1.4	1.5	1.4	1.6	1.7	1.8	1.9	2.1
Industry	1.7	3.1	4.0	5.8	6.2	6.5	7.5	8.1	8.5	10.1	14.5
Residential and tertiary	1.4	2.2	3.8	6.1	6.9	6.9	7.9	9.0	9.9	11.7	16.0
Power generation	1.0	0.7	0.6	2.6	2.6	3.6	2.7	2.3	1.5	2.0	2.0
Total	4.8	6.7	10.6	15.9	17.2	17.9	19.7	21.1	21.7	25.7	34.6
Total consumption of natural gas	3.0	5.1	9.3	15.0	16.0	17.5	18.8	20.1	20.9	25.4	35.0

* Natural, coking plant and manufactured gas

French Energy Policy. Ministère de l'Industrie. Paris. 1979. p.85

Figure 17

	1973	1974	1975	1976	1977
Total primary energy consumption in France (in millions of tons of oil equivalent)	262.1	263.4	246.5	261.7	268.5
Including coal for	45.7	47.4	41.2	48.4	46.9

French Energy Policy. Ministère de l'Industrie. Paris. 1979.
Chapter VII.

more information available to them given by the government. 77 percent of the French respondents (Table VI-A) knew about fossil fuels (oil, coal and natural gas mainly) perhaps because they have a tighter budget, or because they are more conscious about energy conservation. But in Table VIII-D their answers seem quite surprising since they believe their country only depends on fossil fuels by 20 percent and the world by 30 percent. These figures are relatively low. The fact is they are at least 10-15 percent smaller than the average estimates. The reason might be due to their emphasis on nuclear energy which they consider more important (even more important than the other sources because of their new governmental policy).

The Hydroelectric Option -

Hydropower was one of the earliest forms of primary energy to be exploited, and simple primitive water wheels may still be found in many countries. A consequence of the rise in oil prices has been a reoccurrence of interest in small hydro plants (mycrohydro, minihydro are installations that have less than 1MW of installed capacity) to supply small isolated systems which formerly might have been supplied by a diesel-electric generator. Modern hydroelectric installations also have installed capacities in the range of hundreds of thousands of MW. The largest hydro plant in the world at present is under construction at Itaipu in Brazil and will have an installed capacity of 14,000MW.

Hydro development is characterized by high initial investment and low running costs. Many hydro installations are dual purpose, providing both power and irrigation water. Capital costs for hydropower installations vary widely around the world depending on each case.

The potential for increasing hydropower output in many developing coun-

tries is considerable. For example, Africa is estimated to have 22 percent of the world hydropower resources, but only two percent of this has been developed. One problem is that many sites have a potential far in excess of any local market demand for the energy, so that cost per unit of energy delivered becomes prohibitely high. Geological investigations of potential dam sites is necessary as well. The sediment load carried by a river is another important factor which is frequently unknown in many countries. It has an important bearing on the life of any hydroelectric storage reservoir, and is greatly affected by agricultural and other developments upstream from the reservoir. Poor agricultural practices in the catchment area and deforestation of the waters sheds can economically increase the sediment load carried by a river and thus reduce the expected life of a downstream storage reservoir.

Figure 18 shows that installed hydro capacity in the developing countries is expected to be nearly triple the 1976 figure by 1990, but despite this, conventional thermal generating capacity will still predominate.

In Table VI-A Mexicans showed that they knew more about hydroelectricity than the French or the Spanish. There were 32 percent Mexicans who knew about it, 16 percent Spanish and 27 percent French. According to SERI's April, 1980 report, the installed hydroelectric capacity in Mexico was of 4.8 GW and by 1983 it will include an installation of 5.3 additional GW. In 1975, hydroelectric plants represented 39.6 percent of Mexico's installed electric capacity, although that percentage should decrease since few sites remain unexploited. In Table VIII-D Mexicans responded that hydro would be up to 40 percent of their own country's electric production and 30 percent for the world's electric production.

In Spain, hydroelectricity has many things against it such as the fact

Figure 18

AVERAGE SYSTEM COST PER KILOWATT OF INSTALLED CAPACITY
(in 1977 U.S. dollars)

Hydro	1,296
Geothermal	1,564
Nuclear	1,436
Thermal	863

World Bank Publications. August, 1980. p. 35

that the territory has been altered many times in order to build a dam. Towns have been drowned, agricultural land has been changed and ecologically, erosion has been damaging several useful regions leaving dried areas. (This also has happened in Mexico). But during the last two years it has been raining enough in Spain so that savings in energy have been quite significant. By 1985, the PEN-78 expects to produce up to 53,000 GWh which will represent up to 80 percent of the technically exploitable potential and almost 33 percent of the raw potential. Hydroelectricity by 1987 will be up to 15.9 percent of the total energy production. In Table VIII-D Spanish think that hydro will be up to 10 percent of their country's energy production and 10 percent for the world's energy production. The French respondents think hydro will supply France's energy requirements up to 10 percent and 10 percent of the world's as well.

Lacoste (Electricite de France) wrote a report stating that all through the 70s hydroelectricity in the world was of marginal importance and it represented less than five percent of the world's energy suppliers. He gave emphasis to the tough competition that other energy alternatives present, at least in France, hydroelectricity will only represent three percent of France's and the world's energy requirements by the year 2000.

But the Ministere de l'Industrie* states quite the opposite: In 1975, 34 percent of electricity produced in France was generated by hydroplants and attained 17.6 GW for 29 GW of thermal capacity. So, since the country's main interest for this decade is to increase the nuclear capacity, it is difficult to really know which estimate is the closest.

The French respondents (see Table VIII-D) believe 10 percent of the electricity in France and in the world will be generated by hydro plants. This is a good calculation considering it is in between the two other esti-

mates that have been mentioned above.

All these conventional or non-conventional sources of energy should be considered as energy sources that all together will help to solve the energy problem that exists today. None of them will be sufficient enough to achieve this task if its taken by itself, apart from the other sources. Both, industrialized and non-industrialized country's, in today's interdependent world, should consider them seriously in order to contribute to solve today's problems. The energy problem should not be considered only a political issue and action has to be undertaken soon, if not immediately.

A long explanation of the different characteristics of some of the energy options that could be taken by each country in the next few years (depending on their own particular interests) has been included in this study because I considered important to present them in a clear way so that the following detailed solar option is understood better.

Thus, the main objective of this survey is to point out that solar energy in its domestic applications (specially hot water systems) is a very positive non-conventional energy source that if it is taken seriously by the public, it will have a strong impact in the coming years. Consequently, people's attitudes toward solar energy (at least for the energy situation in general) are very important to find out what kind of actions and policies should be taken (by the governments and the individuals) according to what people's needs are. This of course will depend on what kind of information is available to them or how much they know about some of the alternatives that exist to conserve energy.

The Solar Option -

Since the oil crisis of 1973, the people of the industrialized countries have realized that their comfort, their economic development and perhaps, their survival, depend on having enough energy. Hence, it is very important to find energy sources that can be developed with the use of adequate technology at reasonable exploitation prices.

Unlike fossil energy, the Sun is unpowerful in human terms, even if its mass diminishes dispersed in the form of rays about four million tons per second. The sun is about five billion years old which is only about half of its life expectancy. The Earth receives about one tenth of a billion of its energy in rays which is about five to ten times a year the total of known fossil reserves (including uranium).*

There are several reasons why solar energy is advantageous. Solar energy is a free energy (after paying the installation and storage investment); it is more or less evenly distributed (it does not have to be transported) and it is non-pollutant, in the sense that its utilization does not leave any dangerous or nocive products behind. Moreover, the exploitation of solar energy will not change the global radioactivity of the earth-atmospheric system, at least not like nuclear or coal would.

According to the 2000 Global Report to the President estimates the average world demographic growth is 1.7 percent a year and by the year 2000, with 100 million people added each year compared to 75 million in 1975, the world will have about 6.35 billion people. This means that by the year 2000 the demand for energy will be double.

It could seem rather controversial to say that solar energy is a new

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* "Le Soleil et Nous". SOFEDIR. Paris. 1979-80. p. 3.

energy source: it is on the contrary, the oldest energy source in the world. It is the Sun who allows the oceans and other masses of water to stay in their liquid state: he causes the ocean's evaporation that will come back to the stratosphere as rain. The formation of the winds is the result of a fraction of solar energy absorbed by the atmosphere. It is the Sun who nourishes the plants who will transform energy into glucose.

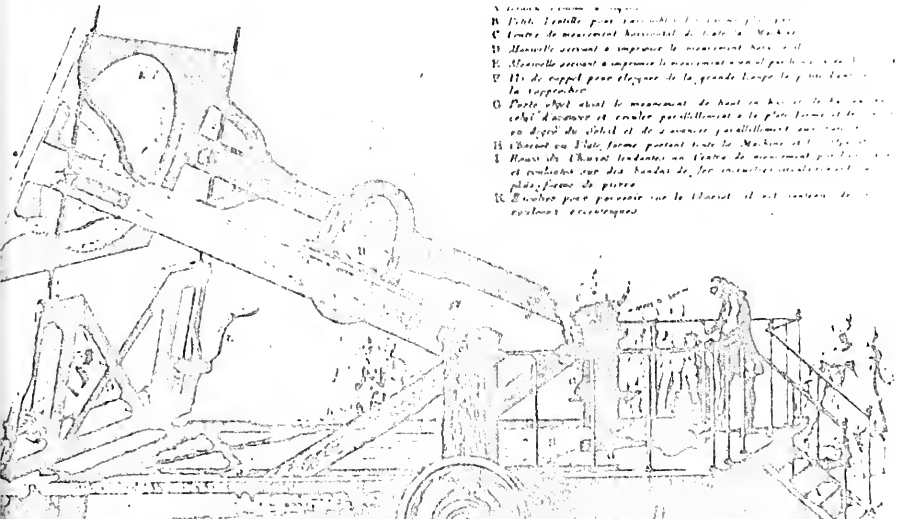
Our industrial fuels are also a result of the Sun's effects. The coal mines were formed by fossil woods and forests of the carboniferous era. Petroleum is the result of the decomposition of microorganisms that the Sun causes. Thus, this extraordinary source of life over the Earth should be directly exploited.

Man has thought of using solar energy since early days. During the third century B.C., Archimedes, was the first one to think about using parabolic reflectors to concentrate the Sun rays and set on fire the Roman navy that attacked Syracuse. Cassini gave Louis XIV a mirror that could melt iron. In the Eighteenth Century, Lavoisier used solar energy in Louis XV's court by using solar rays to produce very high temperatures. His machine was made with two convergent lenses that could melt iron and get temperatures as high as the fusion point of platinum. (see pictures)

Later on, in 1946, French scientists built a mirror with a movible support that produced more than 3000°C in order to get the fusion and volatilization of several substances. In 1953 some researchers made a solar oven of 75KW in Mont Louis. These are only few examples of some solar energy projects that were designed in the past. Ever since the oil crisis in 1973, solar designs have increased enormously. This is why solar energy should not be called a "new" energy source, instead it should be called a "non-conventional" source of energy.

Machine de Mouchot (professeur de physique au lycée de Tours). Il exposa au jardin des Tuileries pour l'Exposition Universelle de 1878 une machine à vapeur solaire entraînant une rotative d'imprimerie.

En 1774 Lavoisier utilise la concentration de la chaleur par des lentilles pour faire fondre des métaux à haute température



"Le Soleil et Nous". SOFEDIR, Paris, 1979.

"Ways of Cooking Meet -
with the sun"

Le Magazin Pittoresque.

Magazin Francais Memoriel

Published in 1870.

MOYEN

DE FAIRE CUIRE LE POT-AU-FEU ET RÔTIR LA VIANDE AU SOLEIL.

Ce moyen est indiqué par un de nos savants professeurs dans un ouvrage récent (1).

On sait que la concentration de la chaleur dans une enceinte vitrée est un fait d'expérience constaté depuis longtemps. La chaleur est plus grande dans les chambres dont les fenêtres ont un double châssis. Au temps des croisades, on eut l'occasion de s'assurer que les Arabes avaient reconnu l'efficacité d'un verre mince pour concentrer la chaleur solaire dans certaines liqueurs : ils se servaient exclusivement d'alambics de verre pour leurs distillations au soleil. Ils faisaient usage aussi de miroirs [illegible] d'acier poli, fabriqués à Damas, pour opérer [illegible] de [illegible]tions.

On lit dans l'Histoire naturelle publiée par Adam Lonicer, en 1551 :

« Moyen par lequel on peut faire infuser dans l'eau diverses fleurs, de façon qu'elle en retienne l'odeur et les vertus.

» Présente un miroir concave à un soleil ardent, puis place entre l'astre et le miroir le vase de verre où est renfermée la substance, de telle sorte que les rayons so-

FIG. 1.

laires se réfléchissent du miroir au verre, comme le montre la figure ci-jointe. »

En 1662, un opticien de Lyon, Villette, construisit un miroir dont le foyer était large comme un demi-louis d'or. « Le point brûlant était distant du centre du miroir d'environ trois pieds (0m,97). Le bois vert prenait feu en un instant. Un petit morceau de fer de marmite était mis en goutte, près de tomber à terre, en quarante secondes. Une pièce de quinze sols était percée en vingt-quatre secondes. »

Vers 1687, le baron de Tchirnhausen construisit un autre miroir, fait d'une lame de laiton, d'une épaisseur double du dos d'un couteau ordinaire. Par le moyen de ce miroir, l'eau contenue dans un vase de terre entrait de suite en ébullition, les œufs qu'on y plongeait étaient cuits dans le moment, et pour peu que l'expérience vînt à se prolonger, cette eau [illegible].

On pourrait citer un grand nombre d'autres [illegible] de Buffon, de Saussure, de [illegible] et de John Herschel.

M. Mouchot [illegible] expose ainsi les résultats qu'il a obtenus.

« J'ai pris [illegible] en verre dont la [illegible] n'était guère plus épaisse qu'une vitre, et dans lequel je pouvais facilement introduire un vase cylindrique en cuivre ou en fer battu dont les bords s'appuyaient sur ceux du bocal ; puis j'ai mis sur le tout un couvercle en verre, et cette espèce de marmite solaire m'a fourni de bons résultats ; car, étant placée au foyer du réflecteur en plaqué d'argent, elle a fait bouillir en une heure et demie trois litres d'eau à la température initiale de 15 degrés.

» Comme cette chaudière était d'une forme assez commode, je m'en suis servi pour différents essais.

» Elle m'a permis, par exemple, de confectionner au soleil un excellent pot-au-feu, formé d'un kilogramme de bœuf et d'un assortiment de légumes. Au bout de quatre heures d'insolation, le tout s'est trouvé parfaitement cuit malgré le passage de quelques nuages sur le soleil, et le consommé a été d'autant meilleur que l'échauffement de la marmite s'était produit avec une grande [illegible].

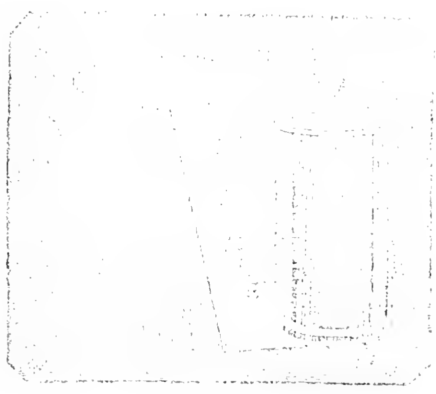


FIG. 2.

» Voici, pour plus de clarté, la figure de l'appareil mis en expérience :

» Un bocal en verre, fermé par un couvercle en verre, contient un vase métallique noirci, dont les bords reposent sur les siens ; enfin, vis-à-vis est le réflecteur en plaqué d'argent frappé par les rayons du soleil qu'il concentre et renvoie sur le bocal.

» Ce réflecteur, cylindrique, est haut de 50 centimètres ; la base est un arc de cercle dont la corde a un mètre.

(1) *La Chaleur solaire et ses applications industrielles*, par A. Mouchot. 1869.

continued

Il est incliné de manière à concentrer les rayons du soleil sur la marmite, et l'on juge sans difficulté que celle-ci est bien au foyer par la lueur qui se forme sur la partie noircie.

» Pour transformer cette même marmite en un four, il m'a suffi de couvrir la chaudière d'un disque de fer battu placé sous le couvercle en fer. J'ai pu, de cette façon, faire cuire en moins de trois heures un kilogramme de pain. Le pain ne présentait aucune différence avec celui que donnent les fours de boulangerie.

» Enfin, en remplaçant les deux couvercles par un chapiteau d'alambic à tête de More, s'adaptant exclusivement à la chaudière, je me suis procuré, sans plus de frais, un appareil très-propre à la distillation de l'alcool au soleil.

» Le chapiteau ayant été mis en communication avec un serpentin plongé dans un courant d'eau froide, tandis que le vase métallique, contenant deux litres de vin, était placé dans le bocal, au foyer du réflecteur, j'ai recueilli l'alcool au bout de quarante minutes d'installation. Comme l'appareil s'échauffait lentement et d'une manière continue, cet alcool était très-concentré et possédait un arome des plus agréables.

» Voici la disposition que j'ai cru devoir adopter comme étant la plus favorable à l'action de mon réflecteur.

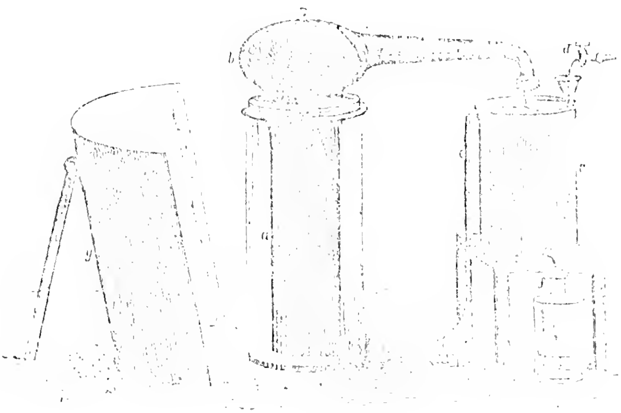


Fig. 3.

» *a* est la chaudière ou marmite enfermée dans le bocal en verre et contenant le vin; *b* est le chapiteau à tête de More, *c*, le serpentin où se condense la vapeur d'alcool; *d*, le robinet par où tombe l'eau destinée à refroidir le serpentin; *e*, l'orifice de sortie pour ce même liquide; *f*, le vase qui reçoit l'alcool condensé, enfin, *g*, le réflecteur.

» Ce réflecteur m'a suffi pour faire rôtir la viande à l'air libre. En l'installant devant une broche garnie d'une pièce de bœuf, de veau ou de mouton, j'ai obtenu en moins de trois heures un rôti de très-belle apparence, et dont la cuisson ne laissait rien à désirer.

» Seulement, pour éviter que les rayons chimiques ne donnent aux rôtis un goût désagréable, il faut avoir soin de placer devant la rôtissoire une vitre jaune ou rouge.

» Je me suis pareillement assuré de la possibilité de faire cuire rapidement au soleil des légumes, des grains, et, à cet effet, je plaçais au foyer du réflecteur un vase clos renfermant de l'eau; puis, quand le liquide entrait en ébullition, je faisais communiquer, à l'aide d'un tuyau, la partie supérieure du vase avec le fond d'un second vase renfermant les légumes ou les grains, et ceux-ci ne mettaient qu'un temps assez court pour cuire à la vapeur. »

Avec un réflecteur ou miroir cylindro-parabolique de près de 5 mètres de long sur 0m,50 de hauteur, et dont l'ouverture était ainsi cinq fois plus grande que celle du miroir d'un demi-mètre carré qui lui avait précédemment servi, l'auteur a pu faire bouillir en trente-cinq minutes cinq litres d'eau prise à la température initiale de 10 degrés.

Cette dernière expérience a eu lieu non au milieu de l'été, mais vers la fin de février et le commencement de mars 1869, le plus souvent entre neuf et dix heures du matin.

L'auteur fait observer qu'on peut donner à la marmite

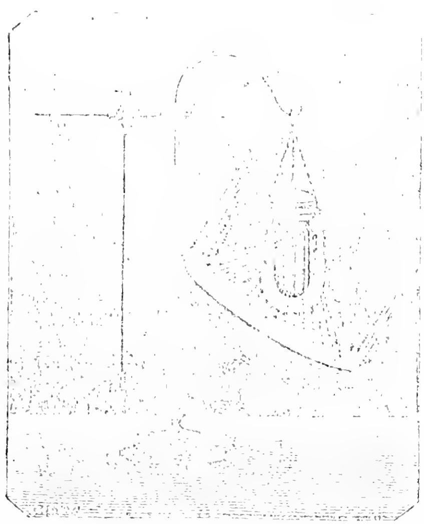


Fig. 4.

solaire indiquée par la figure 2 une forme plus élégante.

- An Available Energy Source -

It should be emphasized that solar energy, unlike coal or petroleum that are substances that have to be transported, conserved, sold, solar energy has a characteristic of being inmaterial because it is presented as a ray. The difficulty lies on the ways of using it efficiently by designing special systems which require certain knowledge of the nature and power of the solar rays: the study or the project of a solar structure should consider the availability of solar rays in a specific place in order to get the most out of it.

Because of its distance (150 million km) the Sun, "illuminates" the Earth only when under a certain angle of incidence. Outside the atmosphere, the amount of energy captured by a surface perpendicular to the sun rays is more or less of 1400 watts per square meter. This energy will be enough to maintain a temperature at which life will develop comfortably. Outside the Earth's atmosphere there is the equivalent to 180 million nuclear power plants of 1000 MG, which means on a clear day, one kw per square meter per day. Unfortunately, solar energy is dispersed and intermitent. The sun does not shine continuously everywhere. Its energy is distributed differently around the earth according to certain attitudes, latitudes, changes of seasons, and day and night. These variations are a result of the Earth's movements around the Sun and of the atmosphere's composition. The sun's rays (more or less 6000^{o}C) after penetrating the atmosphere, are absorbed and diffused throughout the Earth in different ways. This is why some regions of the world, depending on the Sun's or Earth's position, receive more sun rays than others. In the same form, even in a cloudy day, or a foggy day, the clouds act as diffusers that will reflect some energy out of the atmosphere and absorb up

to 10 percent of it. This means that even on a gray day, the sun rays will penetrate the clouds and take heat to the Earth in a diffused way, not a direct one. Thus, it is important to determine if in a certain spot the sun rays will be received in a direct way or a diffused way in order to determine what kind of solar collectors should be used.

Most of the global sun rays received by the stratosphere are absorbed and transformed into heat (without these rays the globe would have a $-240^{o}C$ temperature). So it is the diffused rays of the atmosphere and the clouds that give us light when the sun is being hid by an opaque obstacle or by a cloud.

Against the Solar Option -

During most of this century, solar energy seemed to interest only few people. But since the rise of the price of oil the sun has become a serious alternative source of energy. The point is now how much solar energy, what kind, and when. According to the organizer of the International Sun Day, 40 percent of the United States energy could come from solar energy by the year 2000 if some dramatic moves are done now. But W. Baumol and S. Batey Blackman* argue that many new sources of energy (including solar energy) that are now being suggested as substitutes for oil, entail many indirect costs which make their development prohibitly expensive. On the other hand, M. Maidique in his "Solar America" chapter believes that given reasonable incentives in the United States, solar could provide between a fifth and a quarter of the nation's energy requirements by the end of the century.[1]

[1]Energy Future. Harvard Business School.

* "Unprofitable Energy is Squandered Energy". Challenge Magazine. July-Aug., 1980. p. 28-34.

New technology is not required (in the United States and few other industrialized nations) to realize what solar's potential is today for a more or less 20 percent contribution in the energy production. What is in the way are a series of economic and institutional barriers which must be overcome in the early 1980's if solar energy, like conservation, is to have a fair chance in the marketplace against other conventional sources all over the world. In the case of the United States - or other developed and developing nations - it is realistic to envision a society that relies not on exhaustible hydrocarbons only, but on renewable sources of energy as well.

I think it is very interesting to mention here the reasons why two economists, such as Baumol and Batey-Blackman argue against the unprofitability of new energy sources, in particular, solar energy. They want to warn the public (the focus of this study is to encourage the use of solar water heating when convenient) about the expenses of alternative energy sources that contribute and may actually increase the dependence upon foreign oil and upon those who wish to use oil to dictate foreign policy.

This does not mean that all government outlays designed to induce expansion should not be considered. Subsidies to encourage the development of innovative energy systems, can help to reduce dependence on the oil cartel. But subsidies to new energy sources will not only cost billions of dollars but they will also exacerbate the energy problems. This leads us to a key element that should always be remembered which is that all products (including those that generate energy) use inputs that in turn use up energy. Which means that a unit of labor in order to be energy efficient for instance, must have the same market price as the energy for which it can be substituted in production processes. Simply stated, a costly investment is likely to be one which in one way or another deprives society of a great deal of energy and

when an energy output yields less than the value of the energy input it is thus, unprofitable.

- Net Energy from Solar Sources -

Aside from purely passive uses of solar energy (those that employ no special mechanism for storage, transportation, or conversion into another form, such as electricity), there are three techniques for solar energy use which seem most promising and are discussed more frequently:

1) Low temperature thermal conversion (solar heating and cooling by means of a flat plate collector or series of panels in which sunlight heats up either liquid or air, which is then used directly for space or water heating or to operate a heat-driven cooling apparatus);

2) High temperature thermal electric systems in which sunlight is concentrated (usually by tracking mirrors called heiostats or by one large mirror) to produce heat to drive steam turbines which in turn produce electricity; and

3) Photovoltaic cells (modular crystalline cells, often made of silicon, which convert sunlight directly into electricity).

The energy yield of these techniques has been the subject of considerable controversy, particularly when electricity generation is involved. Much of the discussion of these net energy yields has been framed in terms of energy payback time - the number of years before, say, a solar photovoltaic cell which produces electricity can generate as much energy as was required for its production. And the range of estimates -- many of them offered as though they were incontrovertible figures -- is extraordinary. Baumol and Batey-Blackman begin with two examples:

-(A) house would have to operate more than forty years before the solar cells generate more electricity than was invested in their production, and

we have no idea if solar cells will last that long. (Shinnar, 1976, pp 44-45).

- From a "net energy" perspective, photovoltaics are appealing. Detailed studies of the energy needed to manufacture such cells shows that the energy debt can be paid in less than two years of operation. With more energy-efficient production processes, the energy payback could, theoretically, be reduced to a matter of weeks. (Hayes, 1977, p. 169)

A series of studies of the prospects in the UK for photovoltaic cell techniques for electricity generation from solar energy also yielded many different estimates of the payback period, among them 1.7 years, 7.1 years, 14 years, 34 years, and 71 years! (UK .., 1976, p. 245).

In what appears to be a careful energy study analyzing the net energy contributions of various solar techniques, Baron (1978) found that: "Much of the present technology utilizes materials of construction that are energy-intensive for converting the mineral ores to finished products. Both solar heating and thermal electric systems use large quantities of steel, concrete, aluminium, copper, plastic, and glass. Photovoltaic conversion to electric power is very energy-intensive when reducing silica to high purity silicon" (p. 21). Using methods which are likely to over estimate net energy yields to some degree (see Baumol and Wolff, 1980), Baron examines each of the three basic solar techniques. For solar heating, he calculates the energy expenditures for the components of a typical flat plate collector system (the solar panels, copper piping, storage tank, heat exchanger, antifreeze, assembling material, transportating materials, installation materials and equipment, and operating energy). Baron writes: "the analyses show that the total consumption of fossil and nuclear energy resources to produce and operate solar heated systems is a significant portion of the energy that will be recovered by the solar panels over their operating life (20 years)" (p.5).

He estimates the following payback times for systems located in four United States cities: Washington, D.C., 11.5 years; Boston, 17.5 years; Phoenix, 8.5 years; Charleston, 13 years, for example. He warns us against the poor reliability and installations not properly oriented that might decrease the efficiency of such systems as well.

Thus, Baron concludes: "... solar energy, as presently under development, will not achieve the degree of energy conservation anticipated since it consumes large quantities of non-renewable resources...Clearly, the solar energy development program must concentrate on designs and technological developments that utilize less energy consuming materials if there is any hope of competing with presently energy alternatives. A massive program by the Administration will not achieve the conservation objectives based upon present technology. This premature commitment to solar heating, with its poor conservation and economic prospects, will very likely hurt the cause of solar energy. (p. 10)

In their analysis, Baumol and Batey-Blackman indicate the expansion of solar energy as unprofitable energy-producing activity that is likely to yield a net loss in the economy net stocks. First, investments in energy involve risks for private individuals over and above those experienced by society as a whole. Second, are the limitations of the patent system as a means to protect the interests of investors in energy production processes. These are particularly significant for projects that require a good deal of basic research and whose payoff is likely to occur in the very distant future.

These two grounds illustrate the nature of the criteria which should be used to select energy projects that merit government support. Most economists would undoubtedly advocate some measure for the encouragement of new energy sources such as tariff upon oil importation. An oil tariff would dis-

courage consumption and stimulate conservation measures and would also increase profitability of domestic exploration and the introduction of new energy sources. Other economists would also recommend government support for carefully selected projects. But again it must be emphasized once more that careless selection of the projects to be offered subsidies may not fail to alleviate the energy problem - they are in fact, according to Baumol and Batey-Blackman, likely to intensify it.

The Solar Option -

The term "solar energy" is generally applied to a very wide variety of applications, both direct and indirect. Among the most direct applications are those where solar heat is used immediately, as in simple devices for solar cooking, for drying crops, or for distilling water. Somewhat less direct are applications where the heat is stored and perhaps transferred for later use, as in devices used for heating water (which may be used directly as hot water, or indirectly as to heat a residence). Solar heat may also be transformed to other forms of energy, as to drive devices for refrigeration as well as for heating, it may drive engines for work like pumping water, or it may be transformed into electricity as by photoelectric cells. All these applications will be only mentioned in this report. Emphasis will be given to its domestic use and in particular to hot water systems.

Solar heating and cooling systems use heat collected from the sun's radiation for space conditioning or domestic hot water. The equipment includes solar collectors, thermal storage devices, heat-actuated air conditioners (for solar cooling), and the necessary controls and ancillary equipment. Experts agree that at least in the near future, solar heating and cooling will tend to supplement rather than supplant conventional systems

because the interfaces with conventional equipment and utility-supplied back-up energy are still critical. Present system sizes range from the order of 50 square feet for small domestic water heaters to more than 5000 square feet for large commercial space heating and/or cooling systems.

Solar technology for hot water heat, particularly low temperature needs, can be considered standard technology today. There are readily available systems from commercial manufacturers in both the developed or some developing countries. Low temperature water (less than 100°C) may be supplied by simple flat plate collector systems. These have flat blackened surfaces with a glass cover. The heat transfer may be air or most often, water or another liquid. These systems might have small pumps or rely upon convection circulation. Higher temperatures (up to 300°C) may be derived from point focusing collector systems, though in this case the use of a tracking mechanism for the mirrors and other equipment results in what is considered high technology. The lower temperature hot water systems are readily adapted to incountry manufacture. It is estimated that about 85 percent of the materials, equipment, and labor might be supplied locally; thus the employment and foreign exchange aspect of solar water heat is quite desirable from a developing country's point of view.*

Industrial process heat is an important area of application for solar water heat. Light industry (food processing, textiles, etc. excluding mining and metals, chemicals) typically consume 20 percent of national commercial energy use in developing countries, and commercial fuel use is mostly oil. At the same time, about 60 percent of industrial process heat is hot water, -mostly below 300°C.[1] The limited amount of high temperature steam would

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[1]World Bank Publication #350.

* Sullivan, C. N. "Installation: A key to successful solar program." Solar Age, Sept., 1977.

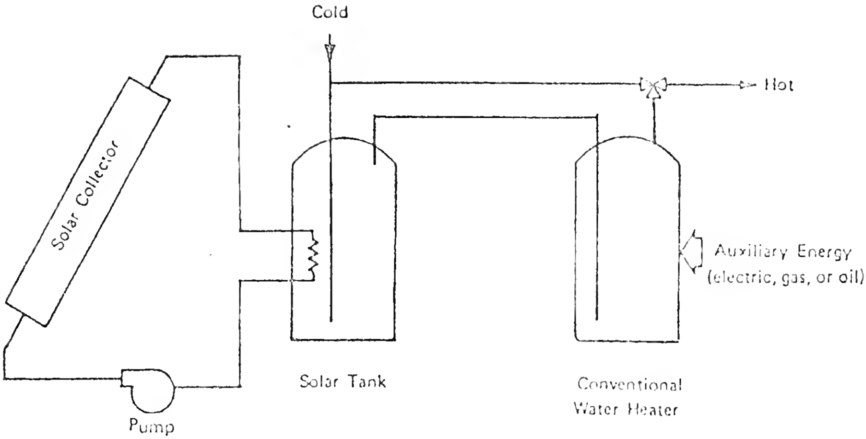
require sophisticated solar technology and it is not considered a likely application in the same frame to the year 2000.

The commercial and residential sectors of many countries consume roughly 20 percent of the national oil. Approximately 20 percent of this is utilized in water heat applications. In rural areas less than half of households use water heat though this is expected to rise by 2000. Increasing the use of hot water is also expected through increasing health standards, hospital use, and the general improvement of living standards. With an annual growth rate of six percent, it is assumed an upper limit of 50 percent for the market penetration.

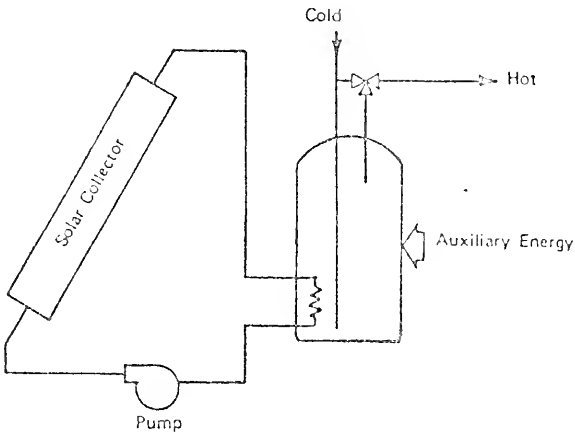
There is relatively little need in developing nations for space heating (except for the mountaineous regions); cooling remains a luxury for the few although it can be important in more advanced countries and tropical countries with a large tourism sector. Given the high cost of solar absorption, cooling systems and their impact upon a relatively small demand for cooling in the developing countries could seem to be on a world scale.

Solar Hot Water Heating - System Design

As shown in Figure 19, a solar water heater will consist of a solar collector, a heat-storage tank, and a heat-transfer loop with the necessary ancillary equipment and controls. (This configuration, as pictured, is typical of the pumped-loop, remote-storage design most common in the United States). This basic solar hot water heater concept is applicable to a range of building types and process applications and can utilize a variety of different types of solar collectors and heat-transfer loops (including different types of heat-exchanger and freeze-prevention methods), and interface with different types of auxiliary energy. Thermosiphon loops and combined storage/collector units



a. Preheater Version



b. Integrated Tank Version

FIGURE 19 SCHEMATIC OF SOLAR WATER HEATING SYSTEMS

are also design options which, to date, have been used most extensively in Europe.

The solar water heater system can be designed either as a preheater with dedicated solar storage or integrated with the auxiliary in such a way that a single tank is used for both solar storage and auxiliary heat addition. The preheater version, with its independent solar storage (frequently equal to daily water consumption), can be readily interfaced with any type of auxiliary water heater. In the integrated tank version which is currently available only with electric auxiliary, the solar heat input is normally supplied near the bottom of the tank and the electric heater element located at approximately midheight, such that the bottom of the tank serves as solar storage and the top as the auxiliary water heater. Both types are in common use, with the integrated type being favored for compactness (and lower equipment cost) and the preheater having advantages of easy interfacing with all auxiliaries, as well as providing extra large storage where water consumption is very high.

Solar water heaters are generally designed to supply from 40-70 percent of hot water load on an annual basis. The economic optimum size, which varies with climatic conditions, is normally a balance between having the system large enough to achieve a reasonably low cost per unit area -- yet not close enough to 100 percent solar to substantially reduce overall efficiency because the system has excess capacity in summer months.

Solar Space Heat and Hot Water

Although there may be certain space-heating-only opportunities, especially when building mass can be used for thermal storage, in most instances solar heating is combined with a hot water system. Figure 20 shows a space heat and hot water system with heat pump and resistance heat auxiliary. In this system, the thermal storage, heated by the solar collector, serves both to

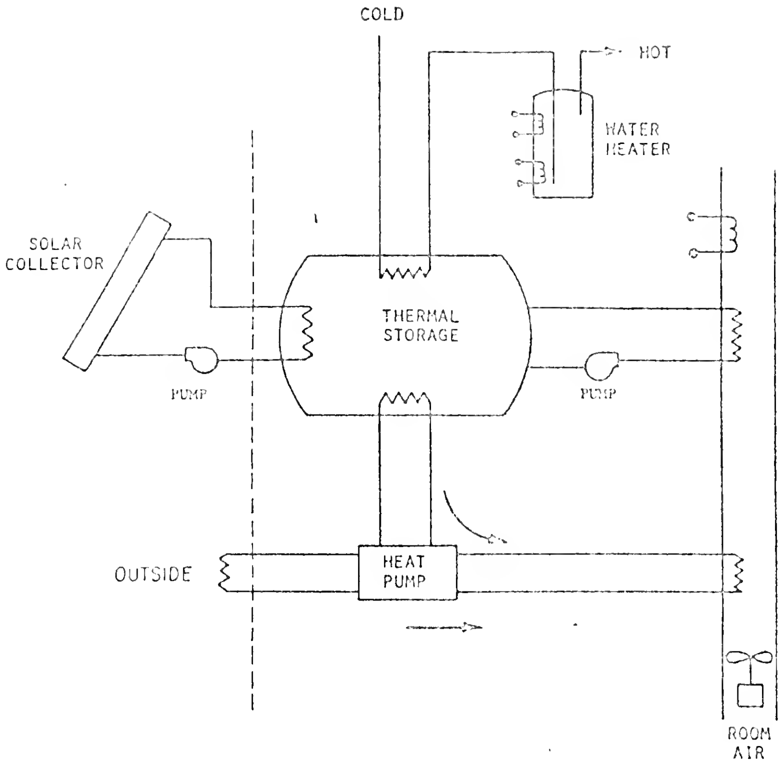


FIGURE 20 SCHEMATIC OF SPACE HEAT AND HOT WATER SYSTEM WITH HEAT PUMP AND RESISTANCE HEAT AUXILIARY

preheat water and to provide space heating. Auxiliary heat, shown here in the form of an electric heat pump and resistance elements, supplies the domestic water and space heating requirements when the temperature of thermal storage is not adequate.

For the sake of generality, the heat pump is shown schematically in a multi-mode configuration, having the dual capability of either supplying auxiliary heat in parallel with the solar system as an air-to-air heat pump, or operating in series with the solar tank as a liquid source "solar-assisted" heat pump. The merits of series vs. parallel operation have received considerable attention. The series liquid-source heat pump will tend to have a higher coefficient of performance (COP)* than the parallel air-source heat pump, since its source temperature is generally higher. (Low source temperature not only reduce COP, but even more importantly, lead to reduced capacity with the resulting need for supplemental resistance heat.) On the other hand, the parallel air-source heat pump operates a smaller fraction of time than the series liquid-source heat pump since, in the parallel mode, solar is allowed to supply heat directly -- and under favorable conditions might supply the total heating load.

In general concept, this system is applicable to a wide range of building types and auxiliary energy sources, since the heat pump can be replaced by fossil fuel heat. The capacity factor of systems involving space heating tends to be lower than hot-water-only systems because of the seasonal variation in load. In northern areas where the seasonally variable space heating load is much larger than the seasonally steady hot water load, it is particularly difficult to achieve both high solar fractions and high capacity factors

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* The COP of an electric heat pump is the dimensionless ratio of heat output to electric power input.

(without employing very large long-term seasonal storage). However, in terms of overall economics, this can sometimes be offset by the larger space heating systems that have lower costs per unit area because of economies of scale.

Combined Cooling, Space Heat, and Hot Water

Figure 21 shows schematically a combined space cooling and heating and hot water system. This system involves the addition of a heat-actuated air conditioner to the hot water supply from the solar tank and is otherwise conceptually the same as the space heating system. The addition of cooling tends to level annual load profiles, but the higher temperatures required for the heat-actuated cooling machines either result in low collector efficiency or may require more efficient, more expensive collectors. Also, the performance of systems involving solar cooling tends to be penalized by the relatively low COP of heat-actuated equipment relative to that of electric vapor-compression devices.

Although by definition it is somewhat independent of solar heating and cooling, energy conservation should always be considered in the design of solar heating and cooling systems. In passive systems, the two are likely to be very closely related, as in the case of large windows which must have adequate multiple glazing and/or curtains or other methods of movable insulation to keep heat loss to a tolerable level. Even with active systems where energy conservation methods may be physically distinct from the solar system, it is extremely important that energy conservation be implemented to the point where incremental improvements in energy conservation would have life cycle costs comparable to those of the solar system.

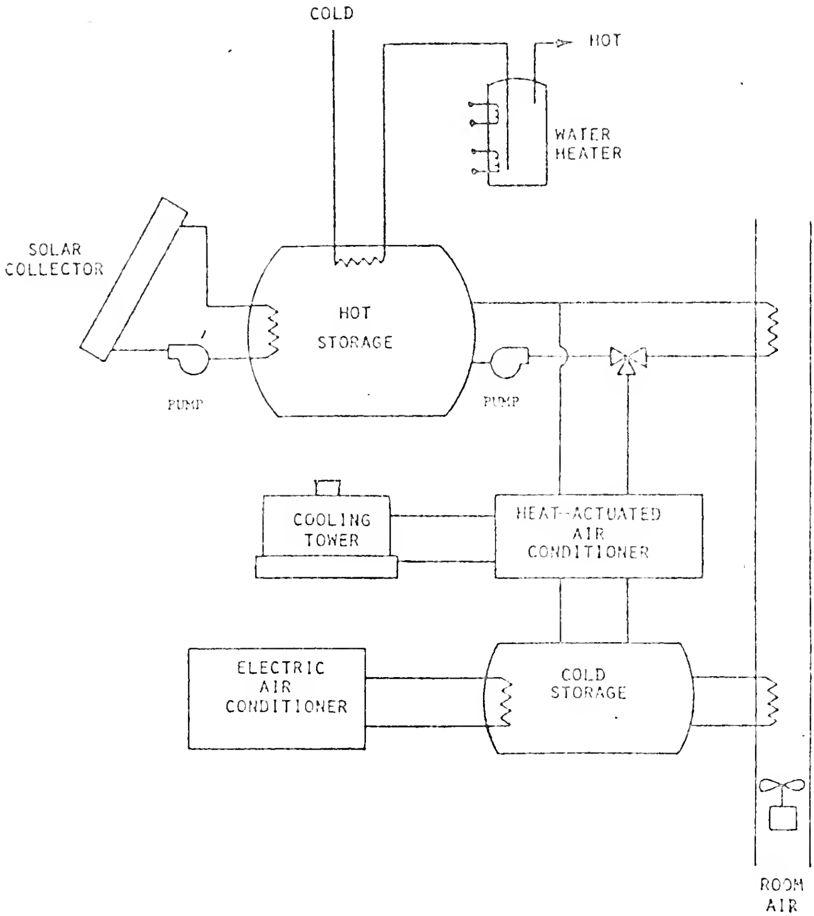

FIGURE 21 SCHEMATIC OF COMBINED SPACE COOLING AND HEATING SYSTEM WITH HOT WATER SUPPLY, USING HOT AND COLD STORAGE

In Favor of the Solar Option -

In order to simplify so many different sources under the term "solar", I will use the Department of Energy's (DOE) classification of solar energy into eight different individual categories which can be organized into three major groups:

1) Thermal (heating and cooling) applications - heating and cooling of buildings - including hot water heating. Agricultural and industrial process heating;

2) Fuels from biomass - Plant matter, including wood and waste;

3) Solar electric - solar thermal electric: such as the power tower. Photovoltaics: solar cells. Wind: windmills. Ocean thermal electric. Hydropower: hydroelectric dams.

Each of the individual categories can be further elaborated, for example, biomass includes not only wood, but also technologies to improve yields of sea algae forms or gasification of manure. The unifying concept here is the effects of solar energy.

Solar requires new ways of thinking about energy. Procuring energy has conventionally meant buying fuel - oil, gas and coal. Most forms of biomass also require buying fuel, but other types of solar energy will mean buying equipment. I insist that the fuel - sunshine - is free. This distinction makes economic comparisons difficult because frequent purchases of fuel must be measured against a one-time investment in equipment.

The spread of "on-site"[1] technology could have significant impact on the traditional distributors of energy - the utilities - which could have a decline in demand for their services. Consequently, the managerial responsibility for generating energy would move out of the hands of the utility

[1]Note: "on-site" derives from the limited area within which the energy produced by a system is consumed - a house, a factory or a small structure.

executive into those of the consumer himself. (This is why this study wants to emphasize on people's attitudes toward solar energy and its domestic application). Still, it should be pointed out that a shift of this sort does not mean the disappearance of the utilities or a revolutionary transformation of the "small is beautiful" kind or a decentralization of any society's energy supplies.

Professor Bruce Russett[1] presents some very interesting arguments in favor of solar energy development, and especially of its application in LDCs. Assuming that particular solar energy applications are cost effective, they may be alleged to serve several additional objectives - objectives that are valued very differently by different individuals or organizations. Some of these objectives might seem beneficial to the "national" interest of a country like the United States which is why I consider them important for this discussion of the study.

1) Widespread use of technology may diminish international political conflicts (wars) among energy importers. Certainly not all wars are over access to scarce raw materials, but many have been. So, perhaps if countries' economic health is less dependent upon large-scale, continuing supplies of a commodity like oil, the potential for conflict over physical or political control over sources of that commodity will diminish;

2) Widespread use of solar technology may reduce the worldwide demand for petroleum products, and hence contribute to a lower price on the world market (and therefore for the United States as an importer);

3) Solar energy is considered to be environmentally benign - little or no atmospheric pollution from particulates, carbon dioxide, etc., or generation of additional heat - even if there are environmental costs in the

[1]An Analysis of a Possible US Solar Energy Policy for LDCs. Political Science Professor at Yale University. 1980.

manufacture of equipment to utilize solar energy, and resources; e.g., land area. Solar energy is also seen as an attractive alternative to the increased use of nuclear energy. It would avoid the problems both of the contemporaneous pollution and of the long-term waste storage. It may be the only alternative for many LDCs who, because of lack of indigenous fuels and a determination to diminish their dependence on foreign fuel supplies, would otherwise "go nuclear". (It has obvious implications for the United States foreign policy which attempts to reduce the potential proliferation of nuclear weapons by reducing LDCs' reliance on nuclear energy for generating electricity);

4) In various ways, the economic development of LDCs is assumed to be beneficial.

a) Wealth in the LDCs is unevenly distributed. Enriched elites and the question "who benefits?" is a critical one in any LDC development project, and especially so for assessing many solar energy applications, where the technologies are new and many require different behavior from that in existing cultural and political patterns;

b) Higher incomes promote democracy and/or political stability. But again, the distribution of income has major implications such as mass political stability. But again, the distribution of income has major implications such as mass political protest or in the imposition of repressive governments to prevent or control protest;

5) Solar energy development seems to offer prospects for substantial economic benefits to countries with enough solar technology (US, UK, France, Germany). For example, widespread world interest in solar energy applications could spur research, development and production in these countries, perhaps leading to new applications appropriate to use in such countries or exports of solar energy equipment. By making the production of solar energy

in any of the so mentioned countries less expensive economies of scale resulting from export markets would make possible greater substitution of solar energy derived from fossil and fissil fuels;

6) Solar energy may offer opportunities for particular forms of development within LDCs, namely forms that could reduce the kind of "dependent development" about which Third World scholars and policy makers have become increasingly critical. Because they already are heavily dependent, LDC governments and citizens frequently seeks ways to diminish their dependence. Consequently, energy sources that could come under reliable control of the LDC itself are particularly attractive. This does not imply a pursuit of full "self-reliance" or economic autarky, but does mean that solar energy applications that are simple and can be easily built and maintained in LDCs, are of great interest to those people. Especially attractive to some are solar energy applications which may be operated on a highly decentralized basis, appropriate to remote villages currently without commercial energy, or where commercial energy is extremely expensive. (Even if some LDC officials still prefer high-technology, centralized energy sources).

These generalizations are possible, but in some degree also the answers will appear highly country-specific, and resistant to generalization. The answers will also vary widely within governments, depending upon ministerial responsibility, personal experience, and age cohorts. The fact that the answers vary widely, and defy easy prediction, does not however diminish the importance of considering the application of solar energy to these dimensions.

According to "Engery in Mexico"*, 40 percent of the country receives more than 20 million $J/m^2/day$ (Joules per square meter per day) and over half receives 15-20 million $J/m^2/day$. The Northwest of Mexico, including Baja California Peninsula, has the greatest solar potential based on insolation

*Energy in Mexico. SERI. April, 1980.

distribution. Mexico has initiated solar water pumping, irrigation and electrification projects for use in outlying villages. The first national solar plan was announced during 1971.

Prospects for renewable energy technologies in Mexico are good. Ragged terrain and diverse climatic conditions encourage a decentralized approach in all but densely populated metropolitan regions. Most regions of the country have idle land areas suitable for large arrays of collectors. High year-round insolation in some areas, particularly the Northwest, offer potential for photovoltaic or thermal conversion energy factories and passive housing. Rural and agricultural areas could utilize solar applications for irrigation and food preservation.

PLANMAES (Plan Mexicano de Aplicaciones de Energia Solar), published in 1979, reflects the federal government's nascent interest in solar energy. This plan included $3.62 million initial investment with cooperation to be provided by the United States, France, West Germany, and Spain. Officials who indicate that solar energy will supply 0.3 percent of the national energy consumption by 1982 predict that figure could be increased to nine percent by the year 2000.

The 1979-82 Rural Electrification Program incorporates plans for using solar energy in isolated villages. Pioneer solar energy efforts involve irrigation and rural electrification demonstration projects through the TONATIUH bilateral program with France. Other solar R&D projects are part of West German and United States bilateral agreements. Pending bilateral energy agreements with both Israel and Canada contain options which could develop into cooperative solar R&D projects.

The UNAM (National Autonomous University of Mexico) has been collecting insolation data. Mexico is an active participant in the solar energy project

of the OAS which has funded university research projects in Mexico on solar thermal applications, photovoltaics and passive housing.

These are just a few very important solar projects being developed in Mexico nowadays that should be included in this discussion.

Taking the results from Table VI-A, the percentage of respondents in Mexico by their knowledge about solar energy and biomass is quite low. For the first one, only 20 percent of the Mexicans interviewed knew about it and zero percent knew about energy from biomass. Whereas for Spain, 33 percent of the Spanish knew about solar energy and zero percent knew about energy from biomass. The most optimistic results were given by the French were 27 percent knew about solar energy and at least five percent knew about energy from biomass.

In Table VIII-D, Mexicans predicted that solar energy (photovoltaics) would supply five percent of their country's total energy consumption, and 10 percent for the rest of the world. Spanish said 15 percent of their country's total energy consumption would be supplied by solar energy and eight percent of the world's energy. Again, as in Table VI-A, French seem to have a more realistic opinion of the role that solar energy would have in their country's energy consumption, 25 percent and 10 percent of the world's energy.

The Spanish PEN-78 and 80 believes that if solar energy technology is developed properly in Spain, by the year 2000, solar energy could supply at least 30 percent of the total energy consumption. Spain's geographical location is very good for solar energy development, especially for the southern regions such as Andalucia, Levante, Castilla and Extremadure.

Photovoltaics nowadays will still be quite expensive in Spain (or anywhere else); about \$1,200-\$1,500 per square meter (m^2), but if it is

industriallly developed it might go down to $20/m^2$ in 1990 for small-scale energy production.

Since the emphasis of this study is to present solar water heating, I proceed by explaining the role of this system in Spain with more detail than for the other solar systems. Spain is a country with special climatic conditions that would make solar water heating quite inexpensive (high level of insolation, and cold winters). Technically, it is easy with simple collectors that could be installed in virtually any building. The only reason why they are still quite expensive is that, economically, it has not been developed competitively in the market. It would be even more inexpensive to install this solar equipment in new buildings, in order to obtain the most efficient results. One of Spain's main intentions, according to PEN-78 and 80 will be to combine solar water heating with photovoltaic in the same surface to use all the available heat (70 percent efficiency) by 1990-2000. Now there are only about 5000 solar water heaters in Spain which is a relatively small number, especially compared to two million ones in Japan, or 200,000 in Israel.* (see Figure 22)

Recently an organized effort in Spain has taken place in solar energy research and development and a projection for the energy source distribution for the end of the century, (when required power is estimated at about 800 Mtec), predicts that if enough funds are provided, solar energy could account for five percent, or about 40 Mtoe, of the total energy production. However, for immediate future, it is recommended by organizations such as the World Bank to concentrate research in water heating through cooperative programs with other nations.

Under the Fourth Plan de Desarrollo (Development Plan), 1976-80, a total of $80 million were allocated for research and development in energy systems.

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* #3 Friends of the Earth. Madrid, 1979. p. 80

Figure 22

Spanish Energy Production

	1978		1987		2000	
	MTEC	%	MTEC	%	MTEC	%
Nuclear . .	2,4	2,4	—	—	—	
Petróleo . .	67,5	66,8	60,0	50,0	45,3	27
Gas natural	1,8	1,8	13,2	11,0	13,4	8
Carbón . .	15,3	15,1	21,6	18,0	20,2	12
Hidráulica	14	13,9	18,2	15,2	25,2	15
Solar directa	—	—	3,6	3,0	37,0	22
Geotérmica	—	—	1,0	0,8	6,7	4
Biomasa .	—	—	1,6	1,3	16,8	10
Eólica . . .	—	—	0,8	0,7	3,4	2
TOTAL	101,0	100,0	120,0	100,0	168,0	100

Que por sectores quedaría:
(by sectors):

	2000	
	MTEC	%
Agricultura	26,88	16
Industria	78,96	47
Transporte	21,84	13
Doméstico y terciario	40,32	24
TOTAL	168,00	100

Modelo Energético de Tránsito. #3 Colección Amigos de la Tierra. Madrid, 1980. p.131

Out of this amount, the allocation for solar energy was $3 million of which two national organizations will manage: CNEE (Comision Nacional de Energias Especiales) and INTA (Instituto Nacional de Tecnica Aeroespacial). CNEE is continuing some work on data acquisition and reduction of insolation and a major project is now a new plant, of advanced pre-fabricated design that is currently under construction for installation on the island of Tabarca, off the east coast of Spain.

France (42-51^{o} N latitude) receives about 110-1800 KWh/m^2 which is about one thousand times more energy than the total energy consumed nowadays. Thus, France could satisfy all its energy needs if she put solar collectors in a 1000 km^2 surface which is 0.2 percent of its territory.*

According to the French Energy Policy (1980), done by the Ministere de l'Industrie, among the overall domestic policy objectives listed in the Conseil Central de Planification (Central Planning Council) on January 29, 1975 was the promotion of oil replacement energy sources, i.e., such renewable energy sources as hydroelectric and geothermal, and especially solar power. It was also stated that applications for solar energy should be extensively developed and expanded.

By 1985, the Planning Council determined that alternative energy sources would provide the equivalent of three Mtoe, representing 1.5 percent of France's energy consumption. By 1990, contributions of the alternative sources may total four or five Mtoe, or even eight or nine Mtoe if the uses of fuelwood are included. For the year 2000, experts foresee ten to twelve Mtoe, provided mainly by solar energy, which would account for about five percent of total energy consumption (not including use of fuelwood). (See

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* Extract from "Le Soleil et Nous" SOFEDIR, 1979, Paris. Caroline Cosse-Maniere. p. 8

Table VIII-D - French estimated that solar energy would represent up to 25 percent of their energy consumption).

In 1978 COMES (Commisariat a l'Energie Solaire) under the authority of the minister of energy was founded, a state-owned, financially independent industrial and commercial organization.

By 1985, the household applications of solar collectors will be increased by 50 percent, thus increasing the production of solar collectors in France with an average annual production of about one million m^2. (see Figure 23). This investment emphasizes the immediate exploitable applications of solar energy which are household water and space heating. Since 1975, 11 million francs have financed 66 demonstration installations, representing 18,000 m^2 of solar collectors, or one fourth of the installed area in France for this period. The financing plans generally cover half of the additional costs associated with the use of solar energy.

In 1978, the government expanded these efforts to private installations by giving individual purchasers of solar water heating systems a 1,000 franc grant from the Directions Departamentales de l'Equipement. Other governmental directions also provided tax deductions, loans at favorable rates of interest for public-financed housing, etc., to encourage development of solar space and water heating.

An important point to be mentioned here is the fact that as of 1980 France ranked second in the world for the production of solar panels equipped with photocells. Several firms produce them at a relatively expensive cost of 100 to 120 francs per watt of installed system. So, unless these cells become more inexpensive, solar energy will still be more important in France with its water heating systems. (See French solar water heater, part of the questionnaire).

Figure 23

ANNUAL PRODUCTION OF SOLAR COLLECTORS IN FRANCE (M^2)*

	Before 1975	1975	1976	1977	1978	Projection 1979	Projection 1985
French PRODUCTION	1,000	3,000	13,000	20,000	35,000	70,000	1 Million
• exports			1,000	2,000	16,000	30,000	
Import of foreign-made equipment			300	1,000	3,500		

* M^2 : Square meters.

French Energy Policy. Ministère de l'Industrie. p.100

France will follow an energy policy that is distributed along three fronts - an ambitious energy conservation policy, accelerated development of national energy resources, and increased diversification of foreign supplies. By 1985, this policy should not only result in savings but should also serve to reduce the share of petroleum 45 percent, which is 50 billion francs.

CONCLUSIONS

Developing countries are now in a position to choose between further commitments to petroleum and development of sustainable solar resources. Many solar options are ready and some are already economically competitive, particularly for use in rural areas where most people in the developing countries reside. Third World countries are becoming cautious (as some developed countries have already become) about imitating advanced industrial nations, and in some cases, are beginning to map out unique strategies based on their indigenous cultures and resources. Transitions to solar energy technologies will not be made without difficulty, however, as baseline data on energy needs and on availability of renewable forms of energy only marginally exists.

A Third World decision to take an active role in harnessing sustainable energy sources would be wise. Although the world is not running out of energy, it is running out of oil. Eighty percent of the world's oil supply will have been consumed during the lifetime of the current generation. Consequently, it is critically important and morally obligatory for all countries, rich and poor, to invest a large fraction of the remaining oil in building an energy system that can be sustained in the post-petroleum era.

As the end of the petroleum era approaches, all nations face some hard choices. Energy, "the capacity to do work" obviously influences economic well-being. To a greater extent than most people realize, history has been shaped by humankind's choice of energy technologies. The use of draft animals, sailing ships, and waterwheels presented new opportunities to our ancestors, and for a time each technology became crucial to the "quality of life". The introduction of the coal fired steam engine was a precondition of the industrial revolution. Fired by oil-based fuels, internal combustion engines shaped the transportation systems of the modern industrial world, which in turn determined settlement patterns. The energy technologies we choose today will have far-reaching effects tomorrow.

The industrial world is designed to run on oil. Massive road building programs dwarf all other public work; automobile production has become central to the economic well-being of entire nations. Developing countries, to different degrees, have emulated the industrial nations, often because energy conversion technologies, construction techniques, manufacturing processes and energy using equipment have been transferred wholesale. Urban settlement patterns in the developing countries rely heavily on energy intensive systems for food, construction, and transportation. Forty-eight of the seventy-four developing countries which import oil depend on it for at least 90 percent of their commercial energy requirements.

Developing nations tend to be more richly endowed than their industrial counterparts with solar insolation. Their populations tend to be dispersed enough to facilitate the exploration of decentralized energy resources: about 40 percent of the people in Latin America; 75 percent in Africa and South Asia and 60-70 percent in North Africa and East Asia still live in rural areas.

In rural areas of the Third World the current high cost of conventional energy, especially electricity, has already made certain solar options economically competitive. Far from being exotic prototypes, many solar devices have already proved themselves simple and practical. Because rural areas already obtain so much of their energy from indirect solar sources (mostly firewood), the initial steps toward a solar economy are increases in the efficiency of usage.

Solar technologies hold many attractions in the developing countries, but a particularly important social advantage is their potential for promoting development in their previously ignored rural areas where it is most needed. Without strong rural development programs, urban migration will exacerbate the already dire urban problems.

Many solar technologies will make economic sense for the Third World before they do in the industrialized countries. Electricity produced from solar energy is a good case in this point. In rural areas of poor countries where no transmission and distribution infraestructure exists, power from centralized plants is not available. The World Bank estimates that rural electrification programs have "reached" about 12 percent of the people in the rural Third World by 1971. Only half of these people - a mere six percent of the rural residents - could afford to buy power. A similar situation occurs with other needs such as crop drying, irrigation, cooking, etc.

Urban areas face the dual problem of providing energy for their already established energy intensive systems and for a large number of poor migration from the rural areas. Because of the similarity between energy needs in industrialized countries and energy needs in the advanced urban areas of developed countries, technologies being pursued in Europe or the United States can often be transferred directly. The urban poor, however, meet

their primary energy needs with conventional sources like kerosene, often subsidized by government, or with traditional fuels like firewood and charcoal. Their problems are more similar to those of rural areas.

Until recently one of the strongest impediments to the development of solar power in the Third World has probably been the industrial world's pursuit of a different course. Most Third World policymakers looked to the advanced industrial states as models and they found no solar-powered societies to emulate. Moreover, because the research and development capacities of the Third World have been limited and the industrial research community has until recently neglected solar energy, innovative work has just begun. Even today, much of the Third World appears reluctant to play a leadership role in developing energy technologies.

However, this situation is changing. The Third World countries are becoming cautious about imitating industrial nations. The most successful Third World leaders have been those able to map out a unique development strategy based upon their nation's indigenous cultures and resources. That the West does not use biogas as an energy source has not, for example, deterred the People's Republic of China from building an estimated 7.1 million biogas plants in the last several years. Brazil likewise developed an internationally recognized ethanol-from-biomass program ahead of all industrialized countries.

The international R&D community has finally begun to apply its genius to the problems and potentials of renewable energy use. Annual expenditures by the United States Government in the past years were of $850 million, and almost all other industrial countries have boosted their solar programs as well. Also, R&D in this area in the LDCs have been improving steadily, and respectable programs are now beginning to evolve in Brazil, Mexico, Spain,

India and Saudi Arabia, among other countries. The World Bank and The United Nations have sponsored many programs of this kind as well.

All this is not to imply that transition to solar technologies will be made without difficulty. A successful solar transition will require, as baseline data, detailed knowledge about energy availability and needs -- information that now only exists marginally. So, comprehensive studies such as this one (even if this is a lower scale) are needed to determine how much energy of each kind is used for what purposes, and how any additional increments of energy would be spent. Moreover, the availability of renewable energy resources at various sites must be surveyed; wind speeds, level of insolation, biological productivity, and current level of use of biomass, among other data must all be gauged.

The emphasis of the survey was given to solar energy because I believe it is a more egalitarian resource than the other alternatives. Sunshine is abundant throughout the Third World and it requires no expensive transmission grid or pipeline system to distribute. Rural people and those living in urban slums are usually the poorest, and renewable resources, especially solar energy in its domestic hot water system, is the most easily tapped to meet rural and urban slum needs. Hot water systems are very easy to install. Elementary solar water heaters can be manufactured rather easily. Hot water for washing would lead to a higher level of personal hygiene, and heating water is one of the simplest tasks to accomplish by anyone with solar energy. A more attractive method, perhaps, would be to build community systems to provide hot water for more people. Boiling water for sterilization, for example, can be produced with concentrating collectors, though without storage, the system would not be usable during evenings or cloudy weather.

These are only a few examples of solar hot water systems and applications.

By having interviewed people in Mexico City, Paris and Madrid, people's knowledge and attitudes toward solar energy and hot water systems was analyzed. In general, I must admit that as of 1980, the population that I interviewed did not know much about energy or solar energy. This demonstrates the point that it is the people who, through adequate information and with the help of the government, will have to make a choice concerning their energy demand and consumption. In the case of the people in the developing countries, it is the policymakers and their government who will probably have to decide what are the best options for them. I hope this will be the beginning of an era of changes that will lead us to a brighter future.

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--- E N C U E S T A .....

SOBRE LO QUE USTED CONOCE DE LAS NUEVAS FUENTES DE ENERGIA, EN PARTICULAR SOBRE LA E N E R G I A S O L A R Y SU APLICACION DOMESTICA ---

El objetivo de ésta encuesta es de determinar el rol tan importante que tiene la información en el desarrollo de las nuevas fuentes de energía. Se entiende por nuevas fuentes de energía: la energía solar, la energía eólica, que es otra forma de energía solar, la energía geotérmica, la energía del biogas o de carburos vegetales, la energía de mareas.

Este cuestionario se basa en la actitud del público ya que es de vital importancia para el desarrollo de cualquier forma de energía en los próximos años, que el público comprenda las alternativas que existen para él y el gobierno, y así poder contribuir al proceso de decisión a través de un adecuado intercambio de información y de opiniones.

El punto central está concentrado en la energía solar y en particular en un proyecto de un calentador de agua solar que está siendo diseñado y se desarrollará en Francia. Esta encuesta será llevada a cabo en diferentes ciudades europeas y americanas para obtener resultados de una perspectiva internacional a nivel informativo y comparar la reacción del público hacia ésta nueva alternativa. Todos los resultados serán comparados esperando así poder proponer soluciones reales para solucionar el problema energético.

Los resultados de la encuesta le serán enviados junto con la información correspondiente al antes mencionado calentador de agua solar. Tenga la amabilidad de responder al cuestionario y enviarlo en el sobre con su nombre y dirección incluídos.

& NOTE por favor que no está usted obligado a responder a todas las preguntas hechas.

δ

I. INFORMACION PERSONAL-

1) NATIONALIDAD ____________

2) MARQUE SEGUN SU EDAD:

entre 18 Años y 35	36 y 50	51 y 65	66 ó más

3) SEXO ______

4) ESTADO CIVIL ____________

5) NUMERO DE HIJOS ________

6) PROFESION ____________

a) Categoría de empleo (Nivel) ____________

b) ¿ En dónde trabaja ? ____________

7) Bajo qué nivel dé SALARIO MENSUAL se encuentra usted:

entre $15,000.00 o mas ALTO	$7,000 a $[illegible].000.00 MEDIO	$[illegible],000 a $6,000.00 MINIMO

8) Marque las casillas siguientes que indiquen el NIVEL DE ESTUDIOS que usted haya cursado:

escuela primaria	secundaria	bachillerato (preparatoria)	universidad

9) ¿ Hace usted mismo ciertas reparaciones domésticas? Marque una o varias:

ELECTRICAS PLOMERIA CARPINTERIA OTROS

10) ¿ Posee usted algún automóbil? ________
¿ Dos o más ? ________

11) ¿Conduce usted sólo a su trabajo ?
SI NO

8

12) ¿Utiliza frecuentemente algún medio de transporte PUBLICO ? ¿Cuáles ? :

TREN AUTOBUS AVION TAXI SUBTERRANEO

13) ¿Cree usted que la energía tiene un papel importante para poder desarrollar su vida diariamente ? SI NO
EXPLIQUE:

a) ¿Considera usted que su equipo para calentar el agua en su hogar es efectivo ? SI NO

b) ¿Depende usted basicamente de la electricidad o del gas ? SI NO

c) ¿Podría usted vivir bien sin su sistema de calefacción ó sin aire acondicionado ? SI NO

14) ¿Qué fuente de energía conoce usted mejor ? (Marque una ó varias):

NUCLEAR SOLAR GEOTERMICA EOLICA

BIOMASA FOSIL NINGUNA OTRA

....

II. HABITACIÓN

15) ¿En qué tipo de costrucción vive usted ?

APARTAMENTO CASA

16) En su hogar, ¿vive sólo o con otras personas? ________
Marque según le corresponda:

a) ¿Con cuántas personas ?

1 a 3	4 a 8	8 a 12	12 ó más

8

17) ¿Hace cuántos años que el edificio fue construido ?

1 a 7	8 a 15	15 a 30	30 ó más

a) Si vive en un edificio de apartamentos, ¿ en qué piso vive ?

1° a 5°	6° a 10°	11° a 15°	más

18) ¿Qué tipo de calefacción utiliza en su hogar ?

CENTRAL	POR PIEZA	OTRO	NINGUÑO

a) Para hacer que ese sistema de calefacción funcione bien, marque el material y el porcentaje que utiliza :

	entre 1% y 10%	11% y 20%	30% - 40%	ó más
LEÑA				
ELECTRICIDAD				
CARBON				
DIESEL, PETROLEO, GASOLINA				
GAS				
OTRO				
NINGUNO				

19) Para que su sistema para calentar <u>agua</u> funcione bien marque según el material y el porcentaje que utilize:

	entre 1% y 10%	11% y 20%	30% - 40%	ó más
LEÑA				
ELECTRICIDAD				
CARBON				
DIESEL, PETROLEO				

ó	entre 1% y 10%	11% y 20%	30% - 40%	ó más
GAS				
OTRO				
NINGUNO				

20) Puede usted calcular la cantidad aproximada de siguientes enegéticos que consuma usted en su hogar MENSUALMENTE:

ELECTRICIDAD (kw-h)	500 [illegible] kw	200 - [illegible]	2,[illegible] kw o más
GASOLINA, DIESEL o PETROLEO (lt)	100 - 300 lt	500 lt	600 - 1,000 lt
CARBON (kg)	—	—	—
LEÑA (kg)	—	—	—
GAS	50 - 100 lt	150 200 lt	[illegible]
OTRO	—	—	—
NINGUNO	—	—	—

21) ¿Tiene usted alguna idea de los litros de agua que consume anualmente?

entre 200,000 lt	500 [illegible] lt	[illegible] lt o más

22) a) ¿Cuánto le cuesta calentar el agua que consume al año?

entre $500 y $1,000	$2 [illegible]	$3,000.00

b) ¿Considera que se consume demasiada agua en su hogar? SI NO EXPLIQUE:

23) Según el funcionamiento de su sistema de calefacción, ¿cuál es su pérdida de energía ?

entre 10% - 20%	30%	40%	50% ó más

a) Segun el funcionamiento de su calentador de agua, ¿cuál es su pérdida de energía ?

entre 10% - 20%	30%	40%	50 ó más

b) ¿Cuántas veces al año tiene que hacer reparar ambos sistemas ?

una a dos veces	2 a 4 veces	5 ó más

24) Indique usted las horas cuando utilize usted más los siguientes aparatos domésticos:

	entre 7 y 12hrs	13 y 17 hrs	18 y 22hrs	22 y 4 hrs
TELEVISION				
LAVADORA DE VAJILLA				
RADIO				
PLANCHA				
HORNO				
ESTUFA				
LAVADORA				
OTRO				
NINGUNO				

....

III. SU OPINION

25) ¿Cuál cree usted que sea el rendimiento total de una central eléctrica ?

	entre 10% y 20%	25% y 35%	40% ó más
DE COMBUSTIBLE			
NUCLEAR			
DE CARBON			

26) La fotosíntesis es el proceso por medio del cual las plantas verdes obtienen energía del sol para transformar las sustancias inorgánicas a orgánicas y así nutrirse. ¿Puede usted estimar el rendimiento de la fotosíntesis?

1%   2%   5%   20%

27) ¿Cree usted que las centrales electro-nucleares desechan más contaminantes térmicos en la atmósfera y los ríos que las otras centrales ?   SI   NO

28) En un orden ascendente indique la mortalidad anual por habitante, en su país, causada por los siguientes accidentes:

	EN CIFRAS ó EN %
NUCLEAR	
AUTOMOBILISTICOS	
CONSTRUCCION	
CORAZON	
CANCER	
OTRAS ENFERMEDADES	
OTROS ACCIDENTES	
NINGUNO	

29) El porcentaje entre las diferentes fuentes de energía, que según usted, sea la más posible a triunfar:

	PARA SU PAIS	PARA EL MUNDO
ELECTRICIDAD NUCLEAR		
HIDROELECTRICIDAD		
FOSIL		
SOLAR (Fotovoltaica)		
BIOLOGICA		
OTRA		
NINGUNA		

30) ¿Qué solución energética propone usted para su pais ? EXPLIQUE:

a) ¿ Existe en realidad un problema energético ?
SI NO ¿Porqué?

b) En caso de una crisis energética, ¿ se veria usted afectado directamente ? SI NO ¿Porqué ?

31) Si mañana uno tuviera que disminuir el consumo de energía, colectivo o individual, a la mitad ¿qué haría usted ? (Marque uno o varios):

a) disminuir la temperatura de la calefacción

b) disminuir el uso de transporte de tipo individual, beneficiando así el transporte de tipo colectivo.

c) instalar un sistema de aislamiento eficiente en su hogar.

d) tomar en cuenta el uso de nuevas fuentes de energía, como la energía solar o nuclear.

e) cambiar un poco su ritmo de vida adaptándose a las circunstancias: por ejemplo, calentar su hogar sólo cuando usted esté dentro de él.

f) otras sugerencias..

IV. EL CALENTADOR DE AGUA SOLAR.

Una parte del sistema de un calentador de agua solar es el captor solar plano que, con una superficie de 6 m^2 en la azotea, tiene la capacidad de calentar hasta 600 litros de agua al día (2 baños o 6 personas), con una irradiación de sol normal y sin costo suplementario al de su instalación. Pero claro está que al aumentar el área de captación aumentará la cantidad de agua caliente obtenida al día.

El calentador de agua solar que aquí se propone está siendo desarrollado en Francia para que cualquier persona pueda adaptarlo fácilmente a todo tipo de construcción. Ciertos científicos están estudiando la posibilidad de su comercialización mundial, ya que además de ser un modelo desmontable presenta otras ventajas superiores a las de otros sistemas.El costo aproximado de cualquier calentador normal, diferente al propuesto, era hace unos años de 12 mil francos franceses (60 mil pesos) ya instalado. El calentador de agua solar, por ser de un procedimiento más simple, tanto en material como en mano de obra, tiene un costo aproximado de 6 mil francos (30 mil pesos) y como su mantenimiento es mínimo, su costo o inversión inicial se amortiza en pocos años. El costo dado anteriormente es para una instalación en construcciones ya terminadas, por lo que en obras nuevas el costo será menor pues no habrá necesidad de hacer ningunos cambios para su instalación.

Otra de las ventajas de éste calentador es el nuevo dispositivo anti-contaminante que se encuentra en el nível de transformación de aguas. Gracias a éste dispositivo, el agua que se utiliza no tiene ningún riesgo de contaminarse dentro del sistema, por lo que prueba ser más seguro y efectivo. Este calentador ha sido muy aceptado en Europa a pesar de que hay muchas menos horas-sol al día que en la República Mexicana; lógicamente aquí en el país tendrá muchos mejores resultados.

En otros países ya se inició la venta de éste calentador de agua que está al alcanze de todos, por eso, si usted conoce en México de algunas escuelas o instituciones en donde se po-

dría demostrar el sistema, por favor indique aquí cuáles y sus direcciones,

Además, si le interesaría recibir más información y documentación al respecto, también indíquelo y se le enviará a donde usted guste junto con las respuestas a las preguntas que usted tenga.

--- ENQUETE ---

SUR CE QUE VOUS CONNAISSEZ DES NOUVELLES SOURCES D'ENERGIE, EN PARTICULIER SUR L'ENERGIE SOLAIRE ET SON APPLICATION AU NIVEAU DOMESTIQUE.

L'objectif de cette enquête est de déterminer le poids de l'information dans le développement des énergies nouvelles. Nous entendons par énergies nouvelles : l'énergie solaire, l'énergie éolienne, qui est une autre forme d'énergie solaire, l'énergie géothermique, l'énergie du biogaz ou des carburants végétaux, l'énergie des marées.

Ce questionnaire se fonde sur l'attitude du public car il est d'une importance essentielle pour le développement de n'importe quelle forme d'énergie dans l'avenir, que le public comprenne les alternatives existentes pour lui et pour le gouvernement, et puisse collaborer ainsi au processus de décision au travers d'une interaction des renseignements et opinions.

La partie la plus importante est centrée sur l'énergie solaire et en particulier sur un projet de chauffe-eau solaire qui est entrain d'être dessiné et va se développer en France. Cette enquête aura lieu dans différentes villes européennes et américaines pour obtenir des résultats d'un point de vue international au niveau de l'information et comparer la réaction du public vis à vis d'une nouvelle alternative. Tous les résultats seront comparés en attendant des propositions concrètes pour résoudre les problèmes énergétiques.

Les résultats de cette enquête seront envoyés à votre adresse avec toute l'information sur le chauffe-eau solaire annoncé ci-dessus. Vous voudrez bien répondre au questionnaire et le renvoyer dans l'enveloppe jointe, en indiquant votre nom et adresse.

* NOTE : vous n'êtes pas obligé de répondre à toutes les questions.

Université Paris 7
2, place Jussieu - 75005 PARIS
DÉPARTEMENT D'ENVIRONNEMENT
Couloir 44-43 - 3e Étage

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I. INFORMATION PERSONNELLE

I) NATIONALITE ____________________

2) QUEL AGE AVEZ VOUS ? ____________________

3) SEXE ____________________

4) ETAT CIVIL ____________________

5) NOMBRE D'ENFANTS ____________________

6) PROFESSION ____________________

a) cadre d'emploi ____________________

b) lieu de travail ____________________

7) Quel est votre salaire ?

MINIMUM 1,700 FF	MOYEN 2,500 FF	ELEVE 3 à 5,000 FF

8) Qu'est-ce que vous avez fait comme études ?

ECOLE PRIMAIRE	LYCEE	BACCALAUREAT	UNIVERSITE Maitrise / Doctorat

9) Etes vous bricoleur ?
Quelles activités en particulier ?

ELECTRICITE PLOMBERIE MENUISERIE AUTRES

I0) Possédez vous une voiture ? deux ou plus

II) Utilisez vous fréquement les transports publics ?

Lesquels ? Train ; Autobus ; Avion ; Taxis ; Métro

I2) Utilisez vous votre voiture pour vous rendre à votre lieu de travail ?

OUI NON

I3) Croyez vous que l'énergie joue un rôle important dans votre vie quotidienne ? OUI NON

Pouvez vous l'expliquer ?

a) Trouvez vous que votre chauffage et votre chauffe-eau fonctionnent bien ?

OUI NON

b) Dépendez vous essentiellement de l'électricité ou du gaz

Lequel ?

c) Pouvez vous vivre bien sans système de chauffage ou sans air climatisé ?

OUI NON

I4) Quelle source d'énergie connaissez vous le mieux ?

8 NUCLEAIRE SOLAIRE GEOTHERMIQUE EOLIENNE
HYDRAULIQUE BIOMASSE FOSSILE AUCUNE AUTRE

II. HABITAT

15) Dans quel type d'habitat vivez-vous ?

Appartement	Maison individuelle

16) Vivez-vous seul chez vous ou avec plusieurs personnes ?

Combien de personnes ?

1 à 3	4 à 8	8 à 12	12 ou plus

17a) De quand date votre habitation ?

1 à 7 ans	8 à 15 ans	15 à 30 ans	plus de 30 ans

17b) Si vous habitez un immeuble, à quel étage ?

1er à 5ème	6ème à 10ème	11ème à 15ème	plus

18) Quel système de chauffage utilisez-vous ?

Central immeuble	Central individuel	par pièce	autre	aucun

a) pour obtenir un bon rendement de votre chauffage, quelle source et quel pourcentage utilisez-vous ?

	entre 1%-10%	11%-20%	21%-30%	31%-40%	50% ou plus
Bois					
Electricité					
charbon					
diesel, essence, pétrole					
gaz					
autre					
aucun					

19) pour obtenir un bon rendement de votre chauffe-eau, quelle source et quel pourcentage utilisez-vous ?

	entre 1%-10%	11%-20%	21%-30%	31%-40%	50% ou plus
Bois					
Electricité					
Charbon					
Diesel, essence pétrole					
gaz					
autre					
aucun					

20) Indiquez sur le tableau suivant le coût total approximatif des sources énergétiques que vous consommez mensuellement dans votre maison ?

électricité (kw/h)			
essence, pétrol, diesel			
charbon			
bois			
autres			

21) Avez vous une idée de la quantité d'eau que vous consommez par an ?

OUI NON

a) combien (en litre) ?

b) avez vous une idée de ce que vous coûte l'eau chaude sanitaire par an ?

entre 1000 - 2000 FF	2500 - 3000FF	3500 - 4000FF	PLUS

c) pensez vous consommer trop d'eau chez vous ?

OUI NON

expliquez :

22) Que pensez vous du système d'isolation de votre maison ?

BON MOYEN INSUFFISANT

23) Selon le fonctionnement de votre chauffage quelle est la perte d'énergie ?

entre 10 - 20%	30%	40%	50% ou PLUS

a) selon le fonctionnement de votre chauffe-eau quelle est la perte d'énergie ?

entre 10 - 20%	30%	40%	50% ou PLUS

b) combien de réglage devez vous faire effectuer par an ?

1 à 2	2 à 4	5 ou PLUS

24) Indiquez les heures auxquelles vous utilisez le plus les appareils suivants ? :

entre	7h. et 12h.	13h. et 17h.	18h. et 22h.	22h. à 7h.
télévision				
lave vaisselle				
radio stéréo				
fer à repasser				
four				
cuisinière				
machine à laver le linge				

III. VOTRE OPINION .

25) Quel est le rendement d'une centrale électrique ?

entre	10% - 20%	25% - 35%	40% ou PLUS
au fuel			
nucléaire			
au charbon			

26) Le processus de la photosynthèse est celui pour lequel les plantes vertes obtiennent ses aliments à travers l'énergie qu'elles reçoivent du soleil. Ainsi, quel est le rendement de la photosynthèse ?

1% 2% 5% 20%

27) A votre avis, les centrales électro-nucléaire, déposent elle plus de déchets thermiques dans l'atmosphère et les rivières que les autres centrales ?

OUI NON

28) Donnez une priorité en ordre de grandeur dans votre pays des accidents et de la mortalité par an par habitant ?

	en chiffres ou %
nucléaire	
automobiles	
construction	
coeur	
cancer	
autres maladies	
autres accidents	
aucun	

δ

29) Le % entre les différentes sources d'énergie que vous estimez plus possible à réussir :

	pour votre pays	pour le monde
électricité nucléaire		
hydroélectricité		
solaire (photovoltaïque)		
biologique		
autres		
aucune		

30) Quelle solution énergétique proposez vous pour votre pays ?

Expliquez :

a) y at-il vraiment un problème énergétique ?

OUI NON

Expliquez :

b) en cas de crise énergétique seriez vous affecté directement ?

OUI NON

expliquez :

31) Si demain on doit réduire de moitié la consommation d'énergie collective ou individuelle, que fairez vous ?

Cochez vos choix

a) réduire le chauffage

b) réduire les transports individuels au profit des transports collectifs

c) mettre un bon système d'isolation chez vous (au bureau)

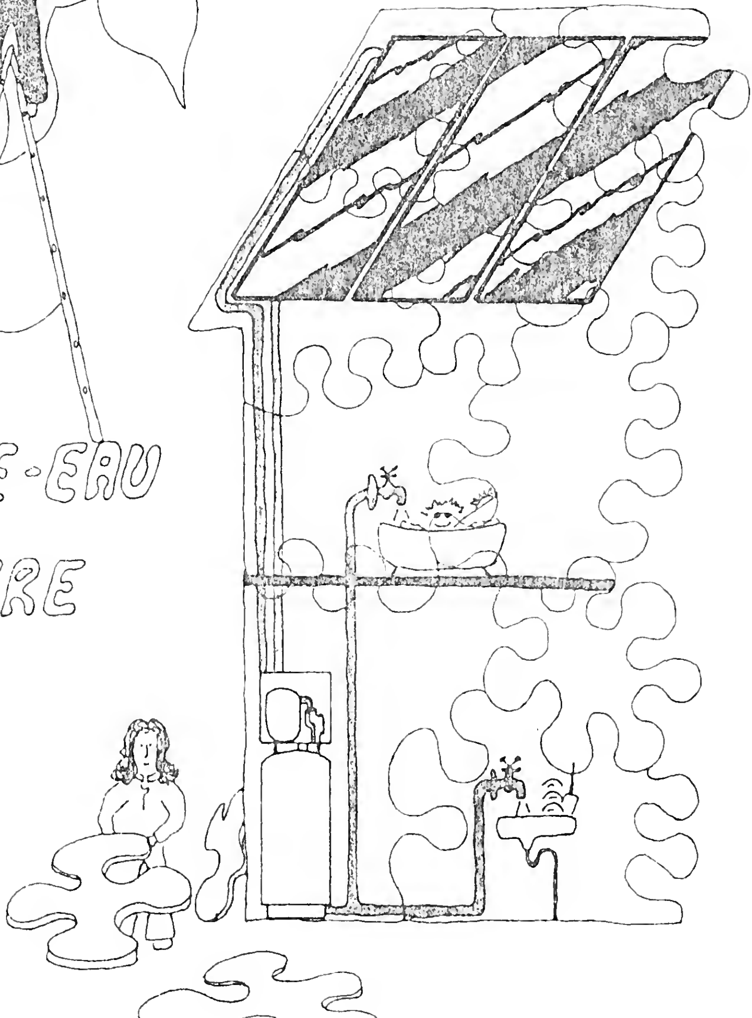
d) considérer l'utilisation de nouvelles sources d'énergie, par exemple solaire ou nucléaire

e) changer votre rythme de vie en vous adaptant aux circonstances : par exemple chauffer votre maison seulement quand vous y êtes

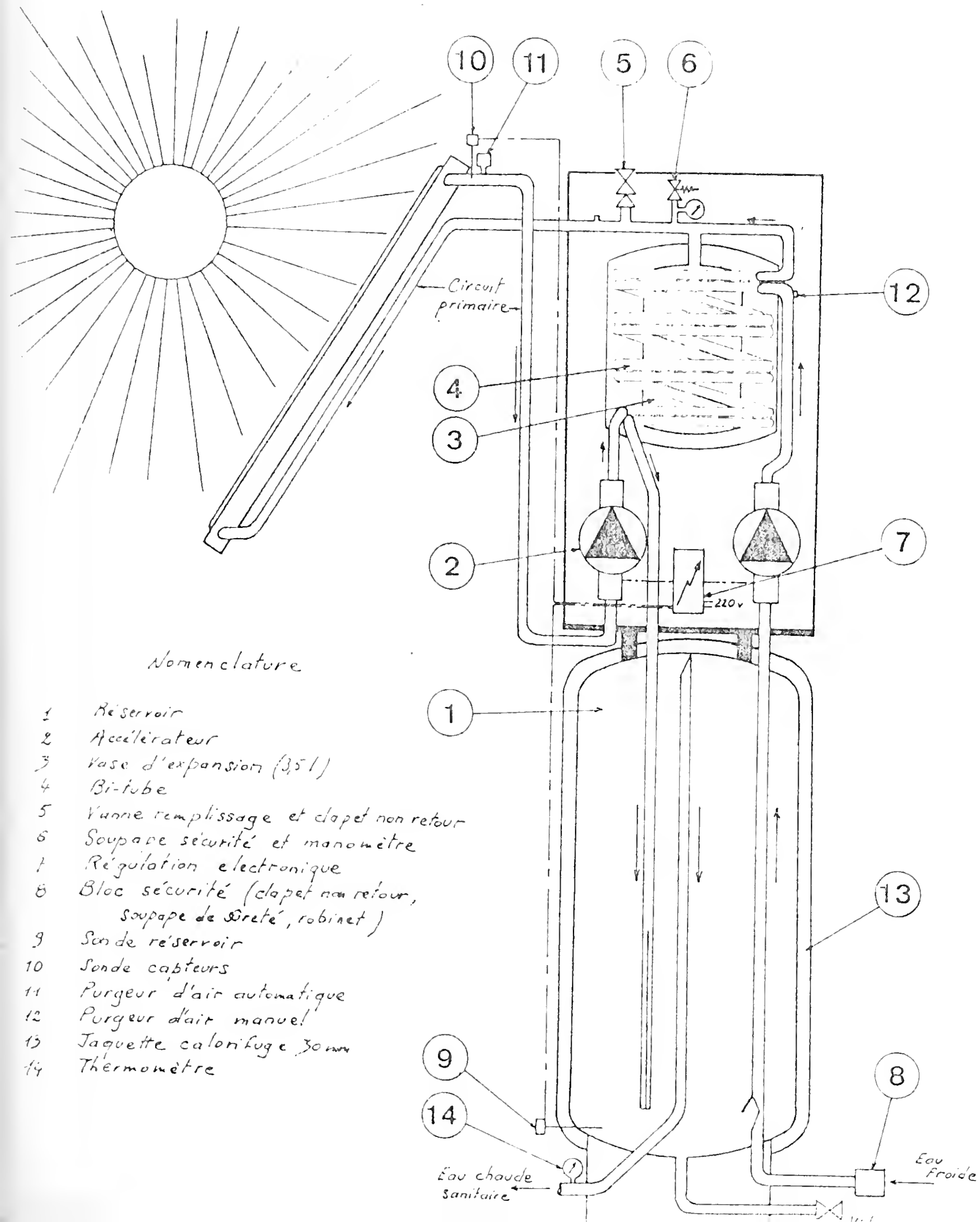
f) autres suggestions

LE CHAUFFE-EAU SOLAIRE

UN KIT
A LA PORTEE
DE TOUS

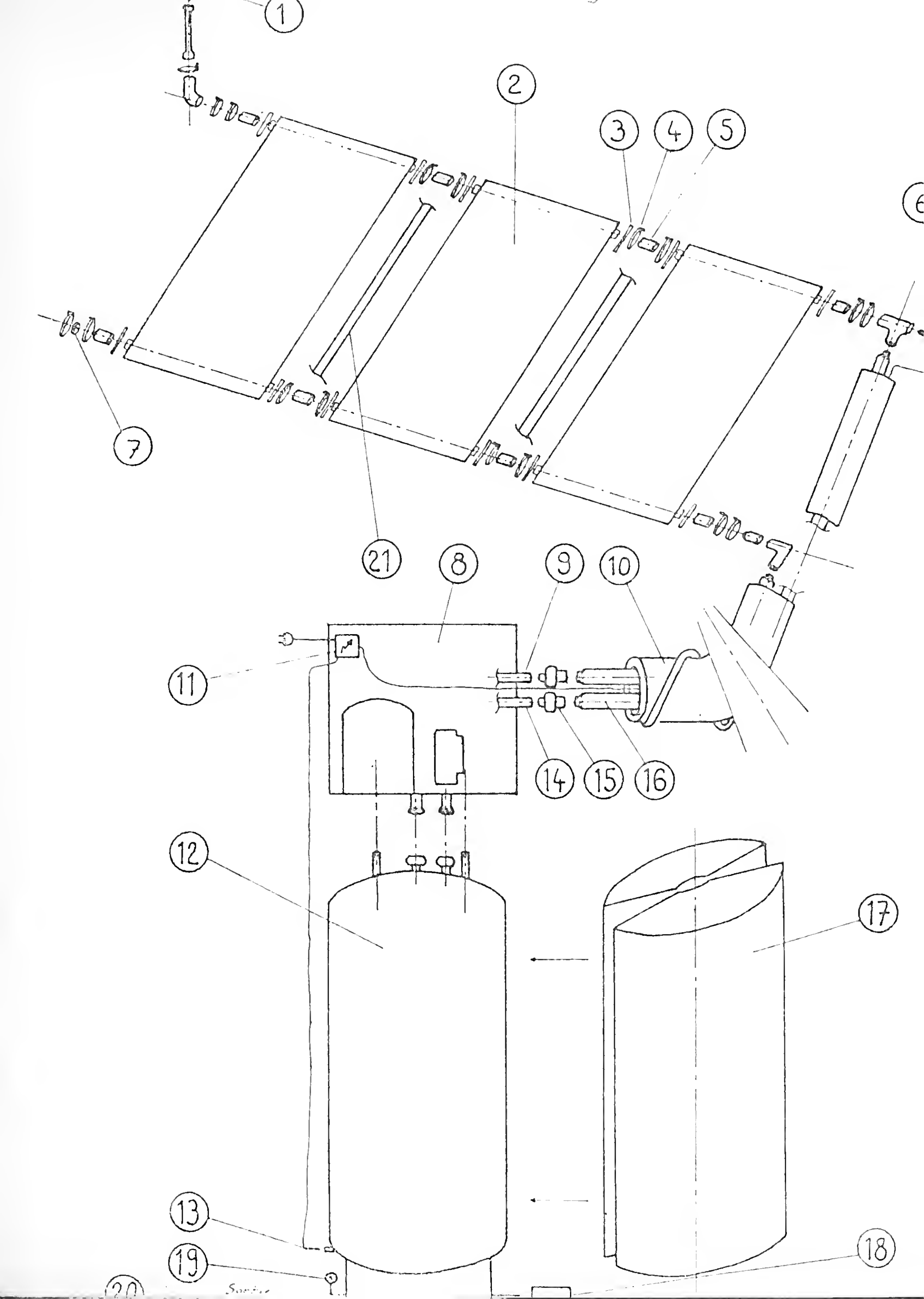


2-1 Schéma de principe de l'installation (sans appoint)



Nomenclature

1. Réservoir
2. Accélérateur
3. Vase d'expansion (3,5 l)
4. Bi-tube
5. Vanne remplissage et clapet non retour
6. Soupape sécurité et manomètre
7. Régulation électronique
8. Bloc sécurité (clapet non retour, soupape de sûreté, robinet)
9. Sonde réservoir
10. Sonde capteurs
11. Purgeur d'air automatique
12. Purgeur d'air manuel
13. Jaquette calorifuge 30 mm
14. Thermomètre


1
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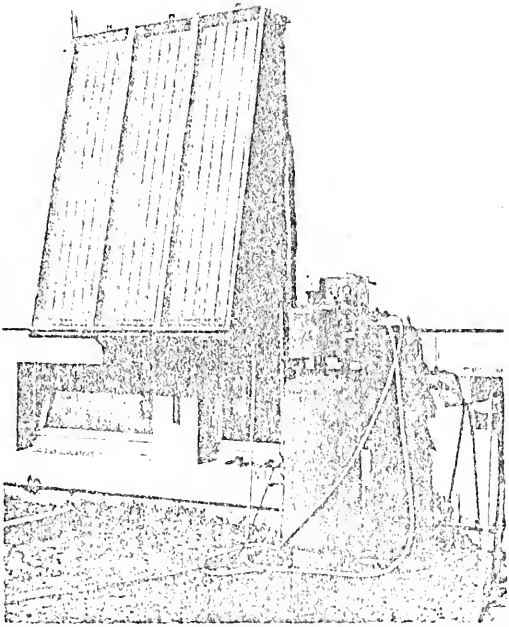
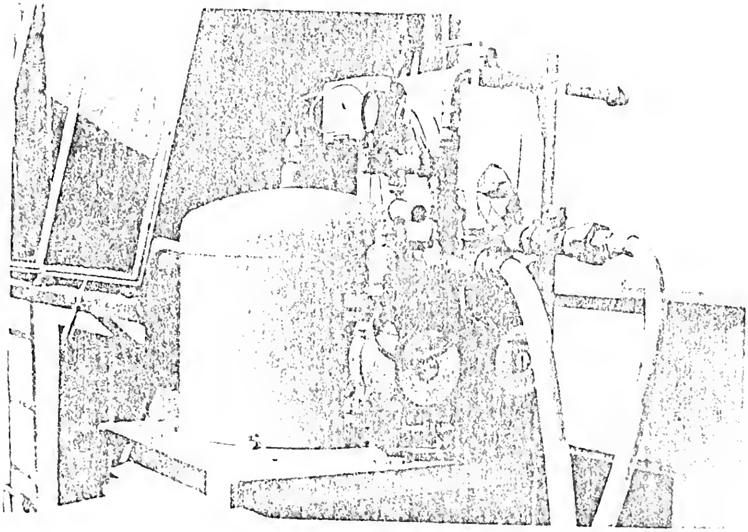




Tables of the Survey

Tables of the Survey - Continued

TABLE I A

Percentage of respondents in each country by gender

	MEXICO			SPAIN			FRANCE			ALL		
GENDER	Female	Male	both	Female	Male	both	Female	Male	both	Female	Male	both
	38% (18)	62% (30)	100(48)	33% (12)	67% (24)	100(36)	44% (16)	56% (20)	100 (36)	38% (46)	62%(74)	100%(120)

TABLE I B

Percentage of male and female respondents in each country by marital status

	MEXICO			SPAIN			FRANCE		
	Female	Male	both	Female	Male	both	Female	Male	both
MARRIED	78% (14)	50% (15)	60% (29)	50% (6)	58% (14)	55% (20)	69% (11)	25% (5)	45% (16)
UNMARRIED	22% (4)	50% (15)	40% (19)	50% (6)	42% (10)	45% (16)	31% (5)	75% (15)	55% (20)
both	100% (18)	100% (30)	100% (48)	100% (12)	100% (24)	100% (36)	100% (16)	100% (20)	100% (36)

TABLE I C

Percentage of married and unmarried respondents in each country by gender

	MEXICO			SPAIN			FRANCE			ALL		
	Female	Male	both	Female	Male	both	Female	Male	both	Female	Male	both
MARRIED	48% (14)	52% (15)	100%(29)	30% (6)	70% (14)	100% (20)	69% (11)	31% (5)	100% (16)	52% (37)	48% (34)	100% (71)
UNMARRIED	21% (4)	79% (15)	100%(19)	38% (6)	62% (10)	100% (16)	25% (5)	75% (15)	100% (20)	33% (15)	67% (30)	100% (45)
both	37% (18)	63% (30)	100%(48)	33% (12)	67% (24)	100% (36)	44% (16)	54% (20)	100% (36)	43% (52)	57% (64)	100% (120)

TABLE I D

Percentage of respondents in three age categories in each country by gender

	MEXICO			SPAIN			FRANCE			ALL		
	Female	Male	both	Female	Male	both	Female	Male	both	Female	Male	both
18 - 35 yrs.	63% (10)	37% (6)	100% (16)	58% (7)	42% (5)	100% (12)	44% (8)	56% (10)	100%(18)	54% (25)	46% (21)	100% (46)
36 - 50 yrs.	25% (4)	75% (12)	100% (16)	33% (4)	67% (8)	100% (12)	57% (8)	43% (6)	100%(14)	38% (16)	62% (26)	100% (42)
51 - 65 yrs.	25% (4)	75% (12)	100% (16)	25% (3)	75% (9)	100% (12)	25% (1)	75% (3)	100%(4)	25% (8)	75% (24)	100% (32)

TABLE I E

Percentage of male and female respondents in each country by age category

	MEXICO			SPAIN			FRANCE		
	Female	Male	both	Female	Male	both	Female	Male	both
18 - 35 yrs.	55% (10)	20% (6)	34% (16)	50% (7)	24% (5)	34% (12)	47% (8)	52% (10)	50% (18)
36 - 50 yrs.	22% (4)	40% (12)	33% (16)	28% (4)	37% (8)	33% (12)	47% (8)	31% (6)	39% (14)
51 - 65 yrs.	23% (4)	40% (12)	33% (16)	22% (3)	39% (9)	33% (12)	6% (1)	17% (3)	11% (4)
all	100% (18)	100% (30)	100% (48)	100% (14)	100% (21)	100% (36)	100% (17)	100% (19)	100% (36)

TABLE II A

Percentage of respondents in each country by level of education obtained

	MEXICO	SPAIN	FRANCE	ALL
HIGH SCHOOL	23% (11)	22% (8)	14% (5)	20% (24)
COLLEGE	77% (37)	78% (28)	86% (31)	80% (96)
total	100% (48)	100% (36)	100% (36)	100% (120)

TABLE II B

Percentage of respondents by level of education by each country

	MEXICO	SPAIN	FRANCE	ALL
HIGH SCHOOL	45% (11)	33% (8)	22% (5)	100% (24)
COLLEGE	42% (37)	32% (28)	26% (31)	100% (96)

TABLE II C

Percentage of respondents in each country by profession

	MEXICO	SPAIN	FRANCE
Architect	20% (12)	11% (4)	20% (6)
Business	10% (5)	27% (10)	33% (14)
Lawyer	21% (10)	27% (10)	27% (10)
Engineer	17% (8)	11% (4)	10% (3)
Physician	10% (5)	0	0
Housewife	17% (8)	25% (8)	10% (3)
total	100% (48)	100% (36)	100% (36)

TABLE II D

Percentage of respondents in each profession
by country of residence

	MEXICO	SPAIN	FRANCE	ALL
Architect	55% (12)	18% (4)	27% (6)	100% (22)
Business	17% (5)	35% (10)	48% (14)	100% (29)
Lawyer	33% (10)	33% (10)	33% (10)	100% (30)
Engineer	53% (8)	26% (4)	21% (3)	100% (15)
Physician	100% (5)	0	0	100% (5)
Housewife	42% (8)	42% (8)	16% (3)	100% (19)
total	40% (48)	30% (36)	30% (36)	100% (120)

TABLE III A

Percentage of respondents in each country by working sector

	MEXICO	SPAIN	FRANCE
Government	42% (20)	33% (12)	38% (14)
Private	45% (22)	55% (20)	62% (19)
Housewife	17% (8)	22% (8)	
Miscellaneous*	- 4% (-2)	-10% (-4)	
total	100% (48)	100% (36)	100% (36)

* note: some housewives who worked did not mention their working sector nor their salary. Therefore, they will be only included in the total figure. (Substracted from the total figures).

TABLE III B

Percentage of respondents in each working sector by country

	MEXICO	SPAIN	FRANCE	ALL
Government	44% (20)	26% (12)	30% (14)	100% (46)
Private	36% (22)	33% (20)	31% (19)	100% (61)
Housewife	42% (8)	42% (8)	16% (3)	100% (19)
Miscellaneous*	34% (2)	66% (4)		100% (6)

* note : refer to note from Table III A.

TABLE III C

Percentage of respondents in each country by profession

	MEXICO			SPAIN			FRANCE		
	Government	Private	both	Government	Private	both	Government	Private	both
Architect	20% (4)	36% (8)	25%(12)	25% (3)	5% (1)	11% (1)	14% (2)	21% (4)	17% (6)
Business	5% (1)	18% (4)	10% (5)	33% (4)	30% (6)	30% (10)	50% (7)	37% (7)	39% (14)
Engineer	20% (4)	18% (4)	17% (8)	9% (1)	15% (3)	11% (4)	8% (1)	10% (2)	8% (3)
Lawyer	35% (7)	14% (3)	21% (10)	33% (4)	30% (6)	28% (10)	28% (4)	32% (6)	28% (10)
Physician	10% (2)	14% (3)	10% (5)	0	0	0	0	0	0
Housewife	10% (2)	-	17% (8)	-	20% (4)	22% (8)	-	-	8% (3)
Miscellaneous*			100% (6)			100% (4)			
total	100% (20)	100% (22)	100%(48)	100% (12)	100%(20)	100%(4)	100%(14)	100% (19)	100%(36)

* note: refer to note from Table III A.

TABLE III D

Percentage of respondents by profession by country of residence

	MEXICO			SPAIN			FRANCE			ALL		
	Government	Private	both	Government	Private	both	Government	Private	both	Government	Private	both
Architect	33% (4)	67%(8)	100%(12)	75% (3)	25% (1)	100% (3)	33% (2)	67% (4)	100% (6)	40% (9)	60% (13)	100% (22)
Business	20% (1)	80%(4)	100%(5)	40% (4)	60% (6)	100% (10)	50% (7)	50% (7)	100% (14)	41% (12)	59% (17)	100% (29)
Engineer	50% (4)	50%(4)	100%(8)	25% (1)	75% (3)	100% (4)	33% (1)	67% (2)	100% (3)	40% (6)	60% (9)	100% (15)
Lawyer	70% (7)	30%(3)	100%(10)	40% (4)	60% (6)	100% (10)	40% (4)	60% (6)	100% (10)	50% (15)	50% (15)	100% (30)
Physician	40% (2)	60%(3)	100% (5)	0	0	0	0	0	0	40% (2)	60% (3)	100% (5)
Housewife	25% (2)		100% (8)		50% (4)	100% (8)			100% (3)	10% (2)	21% (4)	
Miscellaneous*		75% (6)			50%(4)						*16% (3) 52% (10)*	100% (19) - (10)
total	42% (20)	46%(22) 12% (6)*	100% (48)	33%(12)	55%(20) 12%(4)*	100% (36)	38% (14)	62% (19)	100% (36)	38% (46)	54% (61) 8% (10)*	100% (120)

* note: refer to note from Table III A.

TABLE IV A

Percentage of respondents
by monthly income level in each country

	MEXICO		SPAIN		FRANCE	
MINIMUM	$230	22% (11)	$270	13% (5)	$450	14% (5)
MEDIUM	$450	42% (20)	$570	59% (21)	$660	72% (26)
HIGH	$670	36% (17)	$1000	28% (10)	$1190	14% (36)
total		100% (48)		100% (36)		100% (36)

* US $1 equals (1980) 22.50 pesos 68 pesetas 3.8 F francs

TABLE IV B

Percentage of respondents in each country by
income level

	MEXICO	SPAIN	FRANCE	ALL
Minimum	52% (11)	24% (5)	24% (5)	100% (21)
Medium	30% (20)	31% (21)	39% (26)	100% (67)
High	53% (17)	31% (10)	16% (5)	100% (32)
Total	40% (48)	30% (36)	30% (36)	100% (120)

TABLE IV C

Percentage of respondents in each country by type
of heating system

	MEXICO	SPAIN	FRANCE	ALL
Central	63% (30)	22% (8)	66% (24)	52% (62)
By room	17% (8)	78% (28)	34% (12)	40% (48)
none	20% (10)	0	0	8% (10)
total	100% (48)	100% (36)	100% (36)	100% (120)

TABLE IV D

Percentage of respondents livin in apartments or houses by income level and country

	MEXICO				SPAIN				FRANCE				ALL			
	Minimum	Medium	High	All	Minimum	Medium	High	All	Minimum	Medium	High	All	Minimum	Medium	High	All
ARTMENT	50%(5)	30%(3)	20%(2)	100%(10)	14%(4)	69%(19)	17%(5)	100%(28)	15%(5)	76%(26)	9%(3)	100%(34)	20%(14)	66%(48)	14%(10)	100% (72)
USE	16%(6)	44%(17)	40%(15)	100%(38)	12%(1)	25%(2)	63%(5)	100%(8)	0	0	100%(2)	100%(2)	14%(7)	40%(19)	46%(22)	100% (48)
tal	23%(11)	42%(20)	35%(17)	100%(48)	14%(5)	58%(21)	28%(10)	100%(36)	14%(5)	72%(26)	14%(5)	100%(36)	17%(21)	56%(67)	27%(52)	100% (120)

TABLE IV E

Percentage of respondents in three income levels by type of housing and country

	MEXICO				SPAIN				FRANCE			
	Minimum	Medium	High	All	Minimum	Medium	High	All	Minimum	Medium	High	All
RTMENT	45% (5)	15%(3)	12%(2)	20%(10)	80% (4)	90%(19)	50%(5)	78%(28)	100% (5)	100%(26)	60%(3)	94%(34)
SE	55% (6)	85%(17)	88%(15)	80%(38)	20% (1)	10%(2)	50%(5)	22%(8)	0	0	40%(2)	6%(2)
al	100% (11)	100%(20)	100%(17)	100%(48)	100% (5)	100%(21)	100%(10)	100%(36)	100% (5)	100%(26)	100%(5)	100%(36)

TABLE V A

Percentage of respondents in each country
by number of automobiles owned

	MEXICO	SPAIN	FRANCE	ALL
one automobile	79% (38)	77% (28)	66% (24)	7[illegible]% ([illegible]0)
two or more	0	0	0	0
none	21% (10)	0 23% (8)*	0 44% (12)*	8% (10) 17% (20)*– no answer
total	100% (48)	100% (36)	100% (36)	100% (120)

* note: several respondents did not mention if they owned two or no automobiles.

TABLE V B

Percentage of respondents in each country
who use public transportation*

	MEXICO	SPAIN	FRANCE
train	4% (2)	13% (5)	83% (30)
bus	35% (17)	22% (8)	55% (20)
airplane	20% (10)	41% (15)	22% (8)
taxi	35% (17)	22% (8)	27% (10)
metro (subway)	15% (7)	33% (12)	83% (30)
TOTAL	(48)	(36)	(36)

* note: several respondents mentioned more than one kind.

TABLE VI A

Percentage of respondents in each country
by their knowledge about different energy sources*

	MEXICO	SPAIN	FRANCE
Nuclear	16% (8)	22% (8)	77% (28)
Solar	20% (10)	33% (12)	27% (10)
Geothermal	0	13% (5)	27% (10)
Eolian	0	0	22% (8)
Biomass	0	0	5% (2)
Fossil	62% (30)	55% (20)	77% (28)
Hydroelectric	32% (15)	16% (6)	27% (10)
none	0	0	0

* note: several respondents mentioned more than one source.

TABLE VI B

Percentage of respondents with knowledge of
different energy sources by country*

	MEXICO	SPAIN	FRANCE	ALL
Nuclear	18% (8)	18% (8)	67% (28)	100% (44)
Solar	31% (10)	38% (12)	31% (10)	100% (32)
Geothermal	0	33% (5)	67% (10)	100% (15)
Eolian	0	38% (5)	62% (8)	100% (13)
Biomass	0	0	100% (2)	100% (2)
Fossil	38% (30)	26% (20)	36% (28)	100% (78)
Hydroelectric	48% (15)	19% (6)	33% (10)	100% (31)
none	0	0	0	0

* note: several respondents mentioned more than one source.

TABLE VII C

Percentage of respondents in each country by number of people living together

	MEXICO	SPAIN	FRANCE
alone	2% (1)	9% (3)	2% (1)
1 - 3 people	8% (2)	36% (13)	62% (22)
4 - 8 people	60% (30)	55% (20)	36% (13)
8 - 12 people	30% (15)	0	0
total	100% (48)	100% (36)	100% (36)

TABLE VII D

Percentage of respondents by number of people living together by country

	MEXICO	SPAIN	FRANCE	ALL
alone	20% (1)	60% (3)	20% (1)	100% (5)
1 - 3 people	5% (2)	35% (13)	60% (22)	100% (37)
4 - 8 people	47% (30)	31% (20)	22% (13)	100% (63)
8 - 12 people	100% (15)	0	0	100% (15)

TABLE VIII A

Beliefs about rate of efficiency of electrical power plants by country

	MEXICO			SPAIN			FRANCE			ALL			
	Fifteen	Thirty	Forty	Fifteen	Thirty	Forty	Fifteen	Thirty	Forty	Fifteen	Thirty	Forty	All
COAL	100% (48)	0	0	100% (36)	0	0	100% (36)	0	0	100% (48)	100%(36)	100%	(36)100%
NUCLEAR	0	0	100% (48)	0	55% (20)	45%(16)	0	17%(6)	83%(30)	0	22%(26)	78%	(94)100%
FUEL	0	0	100% (48)	27% (10)	33% (12)	40%(14)	0	72%(26)	28%(10)	8% (10)	32%(38)	60%	(72)100%

TABLE VIII B

Beliefs about rate of efficiency of process of photosynthesis by country

MEXICO						SPAIN					FRANCE					ALL				
%	one	two	five	twenty		one	two	five	twenty		one	two	five	twenty		one	two	five	twenty	
	0	20%(10)	42%(20)	37%(18)	100%	0	0	44%(16)	56%(20)	100%	0	5%(2)	22% (8)	73% (26)	100%	0	10%(12)	37%(44)	53%(64)	100%

TABLE VIII C

Beliefs that nuclear electric- power plants deposit more thermal wastes in the atmosphere and rivers than other types of power plants by country

MEXICO			SPAIN			FRANCE			ALL		
YES	NO	BOTH	YES	NO	BOTH	YES	NO	BOTH	YES	NO	BOTH
38% (18)	62% (30)	100% (48)	0	100%(36)	100%(36)	12% (4)	88% (32)	100%(36)	35% (27)	65%(78)	100% (120)

TABLE VIII D

Beliefs about average proportion of energy productivity by type of energy source in respondent's native country and in the world

	MEXICO		SPAIN		FRANCE	
	own country	world	own country	world	own country	world
Nuclear electricity	10%	30%	40%	50%	40%	35%
Hydro-electricity	40%	20%	10%	10%	10%	20%
Solar (Photovoltaic)	5%	10%	15%	8%	25%	10%
biologic	5%	10%	5%	8%	5%	5%
fossil	40%	30%	30%	24%	20%	30%
total	100%	100% (48)	100%	100% (36)	100%	100% (36)

TABLE IX

Beliefs about average proportion of causes of death in repondents' own country

	MEXICO	SPAIN	FRANCE
Nuclear	0	0	15%
Automobiles	12.5%	25%	30%
Construction projects	12.5%	15%	5%
Heart disease	10%	15%	15%
Cancer	10%	15%	15%
Other illnesses	45%	15%	15%
Other accidents	10%	15%	5%
total	100% (48)	100% (36)	100% (36)

* EDUCATION LEVEL in the following countries:

AGE	UNITED STATES	MEXICO	SPAIN	FRANCE
5				
6	elementary			
7		primaria	primaria	primaire
10				
13	middle school	secundaria	secundaria	secondaire
15				
16	high school	preparatoria bachillerato	bachillerato	lycée and baccalaureat
19	baccalauréat	universidad	universidad	
20				université
22	masters	maestría	maestría	
				maîtrise
25	doctorate	doctorado	doctorado	
				doctorat
30 or more				

"Additional Related" Tables - *

* I am including at the end of this study some tables that I have considered very interesting. Thus, I thought they should not be left out. I have called them "Additional Related Tables" and I hope the readers will find them interesting as well.

Table 19 - The United States of Mexico. Population Demography

Table 20 - "Distribucion del Consumo de Energia Primaria" 1977

Table 21 - Ideal Way of Redistributing the Consumption of Energy Among Different Sectors

Article:

France - "Les Combustibles fossiles gardent l'avantage"
Le Monde de l'economie. March 18, 1980 p. 24.

"Energie: et maintenant le "lobby solaire"
Le Monde. Paris March 8, 1980

"Malgré l'Abaissement de Côut des Energies Nouvelles -

Les Combustibles fossiles gardent l'avantage"

PRIX APPROXIMATIFS DES DIFFÉRENTES SOURCES D'ÉNERGIE

(en dollars 1979 par baril d'équivalent pétrole)

Pétrole brut	20 *
Gaz naturel	4-6
Charbon vapeur (États-Unis)	4-5
Charbon vapeur (Europe)	10-15
Charbon vapeur importé par l'Europe	8-14
Électricité d'origine nucléaire	7-11
Gaz de charbon à faible pouvoir calorifique	18-22
Gaz naturel liquéfié importé	15
Gaz naturel synthétique de charbon (États-Unis)	30-50
Charbon liquéfié	30-40
Schistes bitumineux	15-26
Sables asphaltiques	20-33
Énergie solaire (eau chaude à 35°)	40
Biomasse (méthanol, etc.)	40-55

★ Prix moyen du pétrole en 1979. Au début de 1980, le prix moyen a atteint 30 dollars.

Le prix de revient de l'énergie pour l'utilisateur final est évidemment influencé par d'autres facteurs, tels que le coût de stockage, de manipulation, de protection de l'environnement et d'utilisation selon les différentes technologies.

COUT DES APPROVISIONNEMENTS ÉNERGÉTIQUES EN FRANCE

(en centimes par kWh, mars 1980)

Charbon vapeur importé	2,6
Charbon vapeur national, départ mine	4,3 à 4,8
Gaz importé	4,2 à 5,6
Prix du fuel lourd, départ raffinerie	6,1

RESSOURCES MONDIALES DE COMBUSTIBLE FOSSILE

(10[illegible] B.T.U.) (1)

	Réserves prouvées	Réserves ultimes
Gaz naturel	2,2 à 2,5	9,4 à 9,8
Liquides de gaz naturel	0,2 à 0,3	1
Pétrole brut	3,1 à 3,5	8,5 à 10,7
Pétrole synthétique	1,6	14
Charbon	13,7	107,3 à 122,4
		140,4 à 157,9

★ B.T.U. — Basic Thermal Unit. 1 million de B.T.U. = 293 kilowatts heure.

(1) 10[illegible] = 10 milliards de milliards.

Bruno Dethomas

(1) *Total information*, n° 80.

(2) *Le Pétrole et le gaz arabe*, de 16 décembre 1979.

Mardi 18 mars 1980 . . p. 24 *Le monde de l'économie*

- French Energy Policy: trying to make solar energy easily available for everyone. Free information.

Énergie : Et maintenant, le « lobby solaire »

« *Nous voulons devenir le lobby solaire...* » Robert Lion présentait hier le programme pour 1980 du Comité d'action pour le soleil (1), dont il vient d'être élu président. « *Un lobby, ou plus exactement un groupe de pression militant, et non intéressé.* »

Au départ, une constatation. Malgré le renchérissement des coûts de l'énergie, malgré la grande dépendance énergétique de la France, le soleil reste dans l'ombre. Pour beaucoup, c'est une énergie gadget. En francs constants, l'État attribue au Commissariat à l'énergie solaire (C.O.M.E.S.), dirigé vers la recherche, 8 % des sommes qu'il consacrait au Commissariat à l'énergie nucléaire (C.E.A.) il y a vingt ans.

Pas un instant le comité ne songe à remplacer par le soleil les énergies existantes. Mais il estime que l'on peut lui attribuer un rôle beaucoup plus important. Et particulièrement dans le secteur du logement. La désignation à sa tête de Robert Lion, délégué général de l'Union des H.L.M., est, à cet égard, significative.

Il y a deux mois, le ministre de l'Environnement, Michel d'Ornano, voulait, en lançant le concours « 5.000 maisons solaires », donner un « coup de pouce » à l'industrie du solaire Et agir ainsi à la fois sur les coûts et les techniques. On pourra voir ainsi se développer une architecture solaire « active », c'est-à-dire utilisant les capteurs solaires pour le chauffage, ou encore « passive », qui tienne compte du climat, des vents, du relief, qui profite au maximum des apports du soleil et laisse échapper le moins possible de calories. Bref, un habitat beaucoup moins gourmand en énergie.

Mais ni le public, les utilisateurs, ni les installateurs ne dominent encore ces nouvelles techniques. Le comité veut donc former et informer. Premier volet : un « *manifeste pour la France solaire* ». Il sera rendu public le 23 juin, jour de l'anniversaire du jour du soleil. Ce manifeste sera élaboré après consultation d'experts, de chercheurs, de responsables politiques, d'associations, de décideurs publics et privés. Avec la constitution en outre d'un comité parlementaire pour le soleil qui réunira sénateurs et députés désireux d'appuyer une politique solaire ambitieuse, le mot « lobby » prendra tout son sens...

Second volet : l'information. Le comité entend s'attacher surtout aux équipements individuels (et non aux grands projets à échéances plus lointaines). Mais il y a le risque de l'amateurisme, des installations mal calculées qui peuvent déboucher sur une véritable contre-propagande. Pour éviter cet écueil, le comité va mettre sur pied trois « services » :

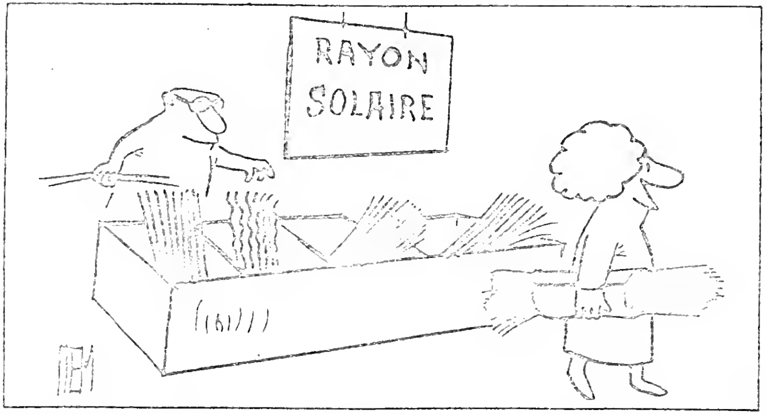
– Conseil en chauffe-eau solaires, recommandant des matériels qui ont fait leurs preuves. Chaque cas donnera lieu à une étude qui permettra de déterminer la surface de capteurs à installer, l'économie à en attendre ;

– Expérimentation et test de matériels : chauffe-eau, installation exploitant la bio-masse en milieu rural ;

– Démonstrations de matériels existants, sur un stand de 3.000 m2 à la Foire de Paris, du 26 avril au 11 amı.

Jacques Laurent.

(1) *Comité d'action pour le solaire, 7, rue du Laos, 75015 Paris. Tél. : 783-45-31 et 567-69-49.*



Le premier magasin de matériels solaires

Le premier magasin de matériels solaires va ouvrir à Paris, le 20 mars. On pourra y trouver tout ce qui concerne l'utilisation et la transformation de l'énergie solaire : chauffe-eau, kit de préchauffage, capteurs pour piscine, panneaux de photopiles, matériels de mesures, d'enseignement, gadgets, livres. Et aussi des conseils pour la réalisation d'installations.

Centre écosolaire, 19, rue Pavée, 75004 Paris. Tél : 887.43.60.

Le Monde. Paris. March 8, 1980.

Table 1

FUTURE POPULATION SIZE, SELECTED COUNTRIES

	Estimated Population, 1980 (000's)	Assumed Year When Replacement Level Fertility is Reached	Year When Stationary Population is Reached	Hypothetical Size of Stationary Population (000's)
China	976,584	2005	2065	1,554,970
India	672,235	2020	2150	1,644,594
Indonesia	141,823	2020	2155	350,424
Brazil	126,258	2015	2075	344,679
Bangladesh	89,473	2035	2155	314,059
Nigeria	84,732	2040	2135	424,900
Pakistan	82,174	2035	2150	331,867
Mexico	69,703	2015	2075	205,326
Philippines	48,170	2015	2075	126,441
Thailand	46,454	2005	2095	102,795
Turkey	45,390	2010	2075	99,928
Egypt	41,831	2015	2105	100,619
Korea, Rep. of	37,809	2005	2070	66,276

Source: 1980 World Bank Population Projections.

World Bank Publications #404. p.76

Table 2

PROJECTED SIZE AND GROWTH RATES OF THE WORKING-AGE POPULATION, SELECTED COUNTRIES, 1975 to 2000

	1975		1980		1985		1990		1995		2000
Nigeria											
Absolute Size (000's)	39,444.8		45,425.5		49,825.5		58,828.1		70,014.5		83,724.8
Average Annual Growth Rate (%)		2.82		1.85		3.32		3.48		3.58	
Mexico											
Absolute Size (000's)	29,951.0		35,842.0		43,078.0		51,583.2		61,271.3		70,824.5
Average Annual Growth Rate (%)		3.59		3.68		3.60		3.44		2.90	
Colombia											
Absolute Size (000's)	13,422.0		15,471.3		18,126.0		20,666.3		23,058.2		25,681.5
Average Annual Growth Rate (%)		2.84		3.17		2.62		2.19		2.15	
Korea, Rep. of											
Absolute Size (000's)	20,088.8		23,334.4		26,256.1		29,000.7		31,571.0		33,594.3
Average Annual Growth Rate (%)		2.99		2.36		1.99		1.70		1.24	
United States											
Absolute Size (000's)	139,366.6		149,325.7		154,987.[illegible]		158,790.1		162,723.2		168,312.5
Average Annual Growth Rate (%)		1.38		.74		.48		.48		.67	

Source: 1980 World Bank Population Projections.

World Bank Publications. #404 . p.78

Table 3

PROJECTED SIZE AND GROWTH RATES OF THE SCHOOL-AGE POPULATION, SELECTED COUNTRIES, 1975 TO 2000

	1975		1980		1985		1990		1995		2000
Nigeria											
Absolute Size (000's)	19,910.5		23,574.7		28,257.2		33,963.0		38,232.1		40,494.7
Average Annual Growth Rate (%)		3.38		3.62		3.68		2.37		1.15	
Mexico											
Absolute Size (000's)	16,568.7		19,318.6		22,401.1		24,123.1		25,301.5		26,724.1
Average Annual Growth Rate (%)		3.07		2.96		1.48		.95		1.09	
Colombia											
Absolute Size (000's)	6,257.0		6,882.6		6,815.3		7,111.6		7,612.6		7,738.3
Average Annual Growth Rate (%)		1.90		-.20		.85		1.36		.33	
Korea, Rep. of											
Absolute Size (000's)	8,915.0		8,632.8		8,608.5		8,290.2		8,387.7		8,915.3
Average Annual Growth Rate (%)		-.64		-.06		-.75		.23		1.22	
United States											
Absolute Size (000's)	37,854.1		35,040.4		33,131.5		34,410.2		35,937.6		35,801.0
Average Annual Growth Rate (%)		-1.54		-1.12		.76		.87		-.08	

Source: 1980 World Bank Population Projections.

World Bank Publications. #404. p.77

Table 4 INCOME AND SCHOOLING IN SELECTED DEVELOPING COUNTRIES

Country	Percentage change in income associated with an additional year of schooling	Proportion of variance in income explained by included variables	Source
Brazil	17.2	.50	Velloso (1975)
Colombia	16.1	.57	Fields (1976)
Colombia	16.9	.32	Fields and Schultz (1977)
Colombia	11.4	.32	Kugler *et al.* (1977)
Cyprus	12.5	.44	Demetriades and Psacharopoulos (1979)
Iran	5.7	.81 a/	Psacharopoulos and Williams (1973)
Kenya	4.8	.42	Thais and Carnoy (1972)
Malaysia	5.3	.80 a/	Hoerr (1973)
Mexico	15.0	.73	Carnoy (1967)
Morocco	15.8	.44	Psacharopoulos (1977)
Taiwan	6.0	.55	Gannicott (1972)
Thailand	3.6	.51	Blaug (1974)
Vietnam	16.8	.16	Stroup and Hargrove (1969)

a/ Used grouped data, hence the high R^2.

Note: The table shows the coeffficient of earnings on years of schooling, in semi-logarithmic earnings functions. The coefficients are not strictly comparable because of the different independent variables used in each study.

Source: Psacharopoulos (1978)

World Bank Publications. #402. p.241

Table 5

RATES OF RETURN TO EDUCATION, PER CAPITA INCOME IN 1968, AND SHARE OF AGRICULTURE IN GROSS DOMESTIC PRODUCT (GDP) IN SELECTED COUNTRIES

				Rates of Return by educational sector and level					
				Social			Private		
Country	Per capita income (US Dollars)	Agriculture's share in GDP (%)	Year	Primary	Secondary	Higher	Primary	Secondary	Higher
Sweden	2,500	6.0	1967	...	10.5	9.2	...	...	10.3
Hawaii	2,495	NR	1959	24.1	4.4	9.2	100.0	5.1	11.0
U.S.A.	2,361	4.0	1959	17.8	14.0	9.7	155.1	19.5	13.6
New Zealand	1,931	NR	1966	...	19.4	13.2	...	20.5	14.7
Norway	1,831	8.2	1966	...	7.2	7.5	...	7.4	7.7
Blegium	1,777	5.5	1967	...	...	9.3	...	...	17.0
Canada	1,774	6.1	1961	...	11.7	14.0	...	16.3	19.7
Great Britain	1,660	3.3	1966	...	3.6	8.2	...	6.2	12.0
Denmark	1,651	12.3	1964	...	...	7.8	...	...	10.0
Netherlands	1,490	8.3	1965	...	5.2	5.5	...	8.5	10.4
W. Germany	1,420	5.0	1964	...	...	...	...	...	4.6
Venezuela	776	7.2	1957	82.0	17.0	23.0	...	18.0	27.0
Puerto Rico	761	12.4	1959	17.1	21.7	16.5	100.0	23.4	27.9
Israel	704	13.5	1958	16.5	6.9	6.6	27.0	6.9	8.0
Greece	478	25.6	1964	...	3.0	8.0	...	5.0	14.0
Japan	464	14.3	1961	...	5.0	6.0	...	6.0	9.0
Mexico	374	18.0	1963	25.0	17.0	23.0	32.0	23.0	29.0
Chile	365	12.6	1959	24.0	16.9	12.2	...	...	...
Colombia	320	30.5	1966	40.0	24.0	8.0	50.0	32.0	15.5
Malaysia	280	28.3	1967	9.3	12.3	10.7	...	...	...
Brazil	261	27.0	1962	10.7	17.2	14.5	11.3	21.4	38.1
+Philippines	250	32.4	1966	7.0	21.0	11.0	7.5	28.0	12.5
Ghana	233	33.7	1967	18.0	13.0	16.5	24.5	17.0	37.0
Thailand	150	NR	1970	30.5	13.0	11.0	56.0	14.5	14.0
S. Korea	146	NR	1967	12.0	9.0	5.0	...	...	...
N. Rhodesia	144	NR	1960	12.4	...	...	...	...	...
Kenya	111	34.6	1968	21.7	19.2	8.8	32.7	30.0	27.4
Uganda	84	59.4	1965	66.0	28.6	12.0	...	...	...
Nigeria	75	55.6	1966	23.0	12.8	17.0	30.0	14.0	34.0
India	73	51.3	1960	20.2	16.8	12.7	24.7	19.2	14.3
Turkey			1968	...	...	8.5	...	24.0	26.0
Singapore			1966	6.6	17.6	14.6	...	20.0	25.4

Note: NR, not recorded; ..., no data.

Source: Psacharopoulos (1973), pp. 62, 85, 189.

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Table 6

RETURNS TO EDUCATION BY LEVEL AND REGION OR COUNTRY TYPE
(in percentages)

		Rate of Return by Educational Level					
		Private			Social		
Country	Survey Year	Primary	Secondary	Higher	Primary	Secondary	Higher
Developing							
Africa							
Ethiopia	1972	35.0	22.8	27.4	20.3	18.7	9.7
Ghana	1967	24.5	17.0	37.0	18.0	13.0	16.5
Kenya a/	1971	28.0	33.0	31.0	21.7	19.2	8.8
Malawi	1978					15.1	
Morocco	1970				50.5	10.0	13.0
Nigeria	1966	30.0	14.0	34.0	23.0	12.8	17.0
Rhodesia	1960				12.4		
Sierra Leone	1971				20.0	22.0	9.5
Uganda	1965				66.0	28.6	12.0
Asia							
India	1965	17.3	18.8	16.2	13.4	15.5	10.3
Indonesia	1977	25.5	15.6				
South Korea	1967				12.0	9.0	5.0
Malaysia	1978		32.6	34.5			
Philippines	1971	9.0	6.5	9.5	7.0	6.5	8.5
Singapore	1966		20.0	25.4	6.6	17.6	14.1
Taiwan	1972	50.0	12.7	15.8	27.0	12.3	17.7
Thailand	1970	56.0	14.5	14.0	30.5	13.0	11.0
Latin America							
Brazil	1970		24.7	13.9		23.5	13.1
Chile	1959				24.0	16.9	12.2
Colombia	1973	15.1	15.4	20.7			
Mexico	1963	32.0	23.0	29.0	25.0	17.0	23.0
Venezuela	1957		18.0	27.0	82.0	17.0	23.0
Intermediate							
Cyprus	1975	15.0	11.2	14.8			
Greece	1977	20.0	6.0	5.5	16.5	5.5	4.5
Spain	1971	31.6	10.2	15.5	17.2	8.6	12.8
Turkey	1968		24.0	26.0			8.5
Yugoslavia	1969	7.6	15.3	2.6	9.3	15.4	2.8
Israel	1958	27.0	6.9	8.0	16.5	6.9	6.6
Iran	1976		21.2	18.5	15.2	17.6	13.6
Puerto Rico	1959		38.6	41.1	21.9	27.3	21.9

(Table continues on following page)

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continued

Table 6

Country	Survey Year	Rate of Return by Educational Level: Private			Social		
		Primary	Secondary	Higher	Primary	Secondary	Higher
Advanced							
Australia	1969		14.0	13.9			
Belgium	1960		21.2	8.7		17.1	6.7
Canada	1961		16.3	19.7		11.7	14.0
Denmark	1964			10.0			7.8
France	1970		13.8	16.7		10.1	10.9
Germany	1964			4.6			
Italy	1969		17.3	18.3			
Japan	1973		5.9	8.1		4.6	6.4
Netherlands	1965		8.5	10.4		5.2	5.5
New Zealand	1966		20.0	14.7		19.4	13.2
Norway	1966		7.4	7.7		7.2	7.5
Sweden	1967			10.3		10.5	9.2
United Kingdom b/	1972		11.7	9.6		3.6	8.2
United States	1969		18.8	15.4		10.9	10.9

Source:

Ghana, Nigeria, Uganda, South Korea, Thailand, Chile, Mexico, Venezula, Israel, Canada, Denmark, Germany, Netherlands, New Zealand, Norway, Sweden, and the United Kingdom (social returns only) from Psacharopoulos (1973, p. 62).

Ethiopia	Hoerr (1974, Table 3);
Kenya	Private rates (Fields 1975, Table II);
Malawi	Preliminary estimate based on Heyneman (1980a);
Morocco	Psacharopoulos (1976, p. 136);
Sierra Leone	Ketkar (1974, Table 5);
India	Pandit (1976) as reported by Heyneman (1980b, p. 146);
Indonesia	Hallak and Psacharopoulos (1979, p. 13);
Malaysia	Lee (1980);
Philippines	ILO (1974, p. 635);
Singapore	Clark and Fong (1970);
Taiwan	Gannicott (1972);
Brazil	Jallade (1977, Table 4);
Colombia	Regression-derived, from Fields and Schultz (1977, Table 8A, Column 4);
Cyprus	Demetriades and Psacharopoulos (1979, Table 9);
Greece	Psacharopoulos and Kazamias (1978, Table 19.1);
Spain	Quintas and Sanmartin (1978, Table 1);

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Table 7

CALORIFIC VALUE OF FUELS

Fuel	BTU/pound
Crude oil	18,300-19,500
Gasoline	20,500
Kerosene	19,800
Gas oil (diesel fuel)	19,200
Ethyl alcohol (pure)	11,600
Liquefied petroleum gases (LPG)	20,500
Anthracite	13,000
Bituminous steam coal	10,200-14,600
Lignite	6,000 - 7,000
Coal briquettes	11,000-14,000
Oil shale	3,000 - 4,000
Wood (air dried) - Pine	6,000 - 9,000
- Hardwood	3,000 - 5,000
Charcoal	11,000-14,000
Peat (air dried)	6,000 - 9,000
Sugar cane bagasse (dry)	8,000 - 9,000
Corn cob	8,100
Straw (dry)	7,000 - 8,000
Dung cakes (air dried)	4,000 - 5,000
Vegetable oil	16,000-17,000
Cotton sticks	5,400
Nut shells	10,000
Solar energy	3,400 BTU per square meter per hour maximum
Natural gas	1,000 " " " " " " " 1/
Biogas	550 " " " " " " "

Note: The above values are approximate and relate to the better grades of fuel. For instance wet wood, or coal with 50% ash content, have far lower calorific values than those shown in the table.

1/ For rough comparison, 6,000 cubic feet of gas has about the same calorific value as one barrel of oil.

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Table 8

AN ENERGY CLASSIFICATION OF DEVELOPING COUNTRIES

NET OIL IMPORTS AS % COMMERCIAL ENERGY DEMAND[b]	NET OIL EXPORTING DEVELOPING COUNTRIES		OIL IMPORTING DEVELOPING COUNTRIES[a]				
	OPEC Members	Non-OPEC	0–25%	26–50%	51–75%	76–100%	
	ALGERIA *GABON* *IRAN* *IRAQ* *KUWAIT* *LIBYA* *QATAR* *SAUDI ARABIA* *UNITED ARAB EMIRATES* *VENEZUELA*	*BAHRAIN* *BOLIVIA* *MALAYSIA* *MEXICO* *OMAN* *PERU* *SYRIAN ARAB REP.* *TRINIDAD AND TOBAGO* *TUNISIA*	*ARGENTINA* *COLOMBIA* Korea, Dem. Rep. *ROMANIA* South Africa	*CHILE* Mongolia *YUGOSLAVIA*	*ALBANIA* *BRAZIL* Korea, Rep. of Lebanon *TURKEY*	Bahamas *BARBADOS* Costa Rica *CUBA* Cyprus Dominican Rep. Fiji *GUATEMALA* Guyana Ivory Coast Jamaica Jordan Malta	Mauritius Nicaragua Panama Papua New Guinea Paraguay Portugal Suriname Uruguay
COUNTRIES WITH ACTUAL OR POTENTIAL FUELWOOD PROBLEM[c]	*ECUADOR* *INDONESIA* *NIGERIA*	*ANGOLA* *BURMA* *CHINA* *CONGO, PEOPLE'S REP.* *EGYPT* *ZAIRE*	*INDIA* Viet Nam, Zimbabwe	*BANGLADESH* Botswana Mozambique *PAKISTAN* Zambia	*AFGHANISTAN* Burundi *GHANA* Malawi Rwanda	Benin Bhutan *CAMEROON* Cape Verde Is. Central African Rep. Chad Comoros El Salvador Eq. Guinea Ethiopia Gambia, The Grenada Guinea Guinea–Bissau Haiti Honduras Kampuchea, Dem. Kenya Lao PDR Lesotho Liberia Madagascar Maldives Mali	Mauritania *MOROCCO* Nepal Niger *PHILIPPINES* Sao Tome and Principe Senegal Sierra Leone Solomon Is. Somalia Sri Lanka Sudan Swaziland Tanzania *THAILAND* Togo Uganda Upper Volta Western Samoa Yemen Arab Rep. Yemen PDR
POPULATION (IN MILLIONS)	320	1180	820	210	245	395	

Countries shown in *ITALICS* are oil and/or gas producers. Table based on UN World Energy Statistics 1978 (except for Bhutan, Botswana, Lesotho and Swaziland whose position in the Table is estimated) and staff estimates of fuelwood situation. Population data from World Development Report, 1980 rounded to nearest 5 million

a/ Excluding countries with 1978 per capita GNP above $3000 and countries with populations of less than 0.5 million that are not members of the World Bank

b/ Imports 1978

c/ Countries were placed in this category if estimated annual consumption of fuelwood could not be sustained through the year 2000, without damage to the ecology, at a level of 0.75 m^3 per capita where income per head (in 1978) was below $300, falling linearly to 0.50 m^3 at $600 and zero at $900. Many countries not included in this group have or will have fuelwood problems in local areas

World Bank Publications. August, 1980. p.5

Table 9

OIL IMPORTING DEVELOPING COUNTRIES: OIL IMPORTS, 1970-90

	1970	1975	1980	1985	1990 Case 1	1990 Case 2	Average Annual Percentage Growth 1970-80	Average Annual Percentage Growth 1980-90 /a
Net Imports /b (Million Barrels a Day)	1.8	4.4	4.5	6.0	7.6	6.4	9.6	5.4
Cost of Imports /c (Billion 1980 US Dollars)	5.4	31.5	49.3	76.6	111.0	93.4	24.8	8.5
Middle Income Countries	4.2	27.9	43.8	67.7	99.3	84.6	26.4	8.5
Low Income Countries	1.2	3.6	5.5	8.9	11.7	8.8	16.4	7.8

/a Growth rates for 1980-90 refer to Case 1.

/b Includes oil used as fuel as well as lubricants, feedstock for fertilizer and petrochemicals, and other industrial uses. Fuel use typically accounts for 90 percent of the total.

/c Average costs per barrel, 1970 and 1975, in 1980 dollars. 1980 price is US$30 per barrel, assumed to increase at 3 percent a year in real terms.

Source: World Bank staff estimates.

World Bank Publications. August, 1980. p.50

Table 10

OIL IMPORTING DEVELOPING COUNTRIES: PRINCIPAL INVESTMENT REQUIREMENTS IN COMMERCIAL ENERGY, 1980-90 /a
(Billion 1980 US dollars)

	Estimate 1980	Annual Average 1981-85	Annual Average 1986-90	Average Annual Percentage Growth Rate 1980-90
Electric Power /b				
Thermal	8.0	11.8	15.4	9.1
Hydro	9.2	13.5	15.1	6.8
Nuclear	1.2	2.1	8.8	30.4
Other	0.1	0.1	0.4	20.3
Subtotal	18.5	27.5	39.7	10.7
Coal /c	0.5	0.7	1.5	15.8
Oil /d				
Exploration	0.5	1.0	1.5	11.6
Development	2.1	2.5	3.2	4.3
Subtotal	2.6	3.5	4.7	8.2
Gas /e	1.0	1.7	2.7	14.2
Alcohol	0.5	0.9	1.2	12.4
Fuelwood	0.5	0.6	1.3	13.6
Refineries /f	1.0	1.8	2.3	11.8
Total	24.6	36.7	53.4	10.9
Note:				
All Developing Countries	34.4	54.4	82.2	12.3

/a Based on Case 1 projections, which are described in Chapter II.
/b Includes cost of transmission and distribution. Estimates assume that capacity requirements will grow at the same rate as in 1973-78.
/c Based on the investments required to develop coal production from 175 million tons of coal equivalent in 1980 to 250 million tce in 1990.
/d Based on the investments required to develop oil production from 2.0 million barrels of oil a day in 1980 to 3.6 mbd in 1990.
/e Based on the investments required to raise gas production from 1.5 mbdoe in 1980 to 2.5 mbdoe in 1990.
/f Estimates assume capital requirements will grow at the same rate as in the recent past.

Source: World Bank staff estimates.

World Bank Publications. August, 1980. p.7

Table 11 COMPARATIVE COSTS OF DOMESTICALLY PRODUCED FUELS FROM DIFFERENT SOURCES /a
(1980 US dollars per barrel of crude oil equivalent)

	Range of Domestic Costs	Imported Equivalent
Primary Energy		
Crude Oil	6.00 to 15.00	30.75 /b
Natural Gas	2.25 " 11.00	27.00 /c
Coal	4.50 " 15.00 /d	14.00 /e
Secondary Energy		
Derived from Crude Oil		
Gasoline - Primary Distillate	9.40 " 21.00	43.50
- Cracking of Fuel Oil	11.00 " 21.00	43.50
Kerosene	11.30 " 25.40	46.00
LPG	10.00 " 25.00	42.50
Fuel Oil	7.20 " 13.50	27.45
Derived from Coal		
Gasoline	40.00 " 60.00	43.50
Synthetic Fuels		
Ethanol from Molasses/ Sugarcane	25.00 " 45.00	43.50 /f
Shale Oil	25.00 " 35.00	30.75
Renewable Energy		
Firewood	8.00 " 20.00	46.00 /g
Charcoal	30.00 " 80.00	46.00 /g

/a Based on delivered cost to major consumers.
/b Based on posted price for Saudi Arabian Light Crude, 1st June 1980.
/c Based on imports of liquified natural gas or fuel oil.
/d Includes cost of infrastructure.
/e Cost of imported steam coal delivered to a coastal location.
/f Cost of imported gasoline.
/g Cost of imported kerosene.

Source: World Bank staff estimates

World Bank Publications. August, 1980 p. 9.

Table 12

DEVELOPING COUNTRIES: PRIMARY COMMERCIAL ENERGY BALANCES, 1980 AND 1990
(Million barrels a day of oil equivalent)

	1980				1990			
	LDCs		OIDCs		LDCs		OIDCs	
	Prod.	Cons.	Prod.	Cons.	Prod.	Cons.	Prod.	Cons.
Oil	13.2	9.2	2.0	6.5	19.4	15.4	3.6 /a	11.4
Gas	3.0	2.1	1.5	1.4	5.2	3.0	2.6	2.6
Coal	2.5	2.6	2.4	2.5	3.7	3.8	3.3	3.4
Hydro	1.9	1.9	1.5	1.5	4.1	4.1	3.2	3.2
Nuclear	0.1	0.1	0.1	0.1	1.2	1.2	1.0	1.0
Other /b	0.3	0.8	0.3	0.4	1.9	3.1	1.5	1.2
Total	21.0	16.7	7.8	12.4	35.5	30.6	15.2	22.8

/a Production level projected in Case 1, as described in Chapter II. The production level in Case 2 is 4.8 million barrels a day of oil.
/b "Other" includes alcohol, other nonconventional primary energy sources, unallocated energy, and exports of gas.

Sources: World Development Report, 1980 and World Bank staff estimates.

World Bank Publications. August, 1980. p. 49

Table 13

DEVELOPING COUNTRIES: POWER GENERATING CAPACITY, 1980-90

	1980		1985		1990	
	Gigawatts	Percent	Gigawatts	Percent	Gigawatts	Percent
Thermal /a						
Oil	90.3	37.4	112.2	31.3	129.1	24.7
Gas	12.5	5.2	29.9	8.3	60.7	11.6
Coal/Lignite	35.1	14.5	58.2	16.2	92.2	17.6
Subtotal	137.9	57.1	200.3	55.8	282.0	53.9
Hydro	99.6	41.3	147.0	41.0	201.3	38.4
Nuclear	3.4	1.4	10.2	2.8	38.1	7.3
Geothermal	0.4	0.2	1.4	0.4	2.3	0.4
Total	241.3	100.0	358.9	100.0	523.7	100.0

/a Estimated fuel breakdown based on primary fuel (some stations are dual fueled).

Source: World Bank staff estimates.

Thermal power will remain the dominant form during the 1980s although its share will decline; coal- and gas-fired generation will increase at the expense of oil-fired. Hydropower capacity is expected to double, although its share in total electricity production will drop slightly. Nuclear power, presently confined to a few developing countries, will increase its share of production substantially during the decade.

World Bank Publications . August, 1980. p. 45

Table 14

ELECTRICITY PRODUCTION IN DEVELOPING COUNTRIES, 1980-90

	1980		1985		1990	
	Terawatt Hours	Percent	Terawatt Hours	Percent	Terawatt Hours	Percent
Thermal						
Oil	272	30.5	346	25.0	388	19.2
Gas	55	6.2	131	9.5	213	10.5
Coal/Lignite	154	17.2	255	18.4	404	20.0
Subtotal	481	53.9	732	52.9	1,005	49.7
Hydro	394	44.2	592	42.7	777	38.4
Nuclear	15	1.7	51	3.7	225	11.1
Geothermal	2	0.2	10	0.7	15	0.8
Total	892	100.0	1,385	100.0	2,022	100.0

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Table 15 OIL IMPORTING DEVELOPING COUNTRIES: COMPARATIVE COSTS OF POWER GENERATION BASED ON VARIOUS TYPES OF FUEL
(Delivered cost to major consumers)

Generator Type		Investment Cost 1980 US Dollars per kW Installed a/	Fuel Cost 1980 US¢/kWh	Power Cost 1980 US¢/kWh
Hydropower	- Large, High Head	1100	n.a.	2.4
	- Low Head Mini-Hydro	3500	n.a.	12.7
Diesel	- Large, Heavy Oil Fuel Coastal Location	1000	4.2	6.7
	- Small, Light Oil Fuel Inland Location	800	10.9	13.2
Steam	- Large, Gas-Fired	800	0.4	2.4
	- Large, Coal-Fired	1000	2.7	5.2
	- Large Oil (Imported) Fired	800	5.5	7.5
	- Small, Heavy Oil-Fired Inland Location	1400	7.3	11.4
	- Small, Wood-Fired	1500	3.0	10.0
Geothermal	- Dry Steam Field	1400	n.a.	3.0
	- Wet Steam/Hot Water Field	2800	n.a.	6.0
Nuclear	- Large Multiple Units	1600	1.0	5.1
	- Single Small Unit	2200	1.0	7.4
Solar Photovoltaic		20,000-30,000/b	n.a.	100-300
Wind Generator		5,000-15,000/b	n.a.	30-100

n.a. Not applicable.

/a Investment cost includes costs of transmission and distribution.

/b Both solar energy and wind power are intermittent energy sources which require storage to make energy available on demand at all times. Investment costs given above are system costs with storage included.

Source: World Bank staff estimates

World Bank Publications. August, 1980. p. 43

Table 16

PROSPECTS FOR ENERGY PRODUCTION IN DEVELOPING COUNTRIES

shows the present production of energy by source, and projections for 1990, for the world as a whole, for the oil exporting developing countries and for the majority of developing countries which import oil.

WORLD COMMERCIAL PRIMARY ENERGY PRODUCTION, 1980-90

	Million Barrels a Day of Oil Equivalent						Average Annual Percentage Growth, 1980-90		
			Developing Countries					Developing Countries	
	World		Oil Exporters		Oil Importers		World	Oil Exporters	Oil Importers
	1980	1990	1980	1990	1980	1990			
Oil	63.1	77.3	11.2	15.8	2.0	3.6	2.1	3.5	6.1
Gas	27.0	45.0	1.5	2.7	1.5	2.5	5.2	6.1	5.2
Coal	41.3	62.5	0.1	0.4	2.4	3.3	4.2	14.9	3.2
Hydro	3.7	6.8	0.4	0.7	1.5	3.2	6.3	5.8	7.9
Nuclear	0.9	4.2	(.)	0.2	0.1	1.0	16.7	n.a.	25.9
Unallocated & Other	1.8	5.7	(.)	0.4	0.3	1.6	n.a.	n.a.	n.a.
Total	137.8	201.5	13.2	20.2	7.8	15.2 /a	3.9	4.4	6.9

(.) Less than 0.1 mbdoe.
n.a. Not applicable.
/a Adjusted for Case 1 production estimates, described in paragraph 2.08.

Source: Bank staff estimates from data underlying World Development Report, 1980, Table 2, p. II-67.

World Bank Publications. #350. p. 90

Table 17

Thermal Electric Power Generation Per Category of Fuel in 1978 in France

	Fuel Consumption	Power generation GWh	%
Coal (Mt)	23.7	54,500	37
Oil (Mt)	12.1	52,200	35
Natural gas ($10,9 m^3$)	1.6	5,500	4
Blast furnace or other gas ($10,9 m^3$)	4.4	7,700	5
Lignite (Mt)	0.5		
Uranium (Mtoe)	6.4	28,800	19
TOTAL		148,700	100

French Energy Policy. Ministere de l'Industrie. p.77

Table 18

French consumption of primary energy

In Mtoe	1960	1965	1970	1973	1976	1977	1978/1985 estimates	
Coal	46.8	45.7	38.1	30.5	32.3	31.4	32	28
Oil	26.9	49.7	87.3	116.3	108.9	105.2	106	101
Natural gas	2.9	5.1	9.3	15.0	18.8	20.1	21	36
Hydraulic	9.0	10.5	12.5	9.9	11.2	17.9	17	14
Nuclear	–	0.2	1.1	3.1	3.3	3.8	6	43
New energies	–	–	–	–	–	–	–	2
TOTAL	85.6	111.2	148.3	174.8	174.5	178.4	182	225

Between 1960 and 1978 French energy consumption has more than doubled. It rose from 85.6 Mtoe to 182 Mtoe. In this rise the share of the various energy sources was considerably changed. The coal share dropped from 55% to 18%, the oil share rose from 31% to 58% and the gas share from 3% to 12%. Hydroelectricity remained relatively stable around 10%. Nuclear power made a delayed appearance but considerable upsets are expected in the future (broken line). Coal is continuing to fall off slowly. Oil has steadied and so has hydroelectric power. All the growth has gone over to gas (which is increasing from 21 to 35 Mtoe) and above all to nuclear power which reaches 43 Mtoe. The new energies are just beginning to count.

French Energy Policy. Ministère de l'Industrie. p. 8

OBJECTIVES FOR 1985

The objectives for energy savings are today as follows:

	Forecast of consumption without conservation measures (1985)	Forecast of consumption after conservation measures (1985)	Savings (absolute value)	Savings %
Industry and agriculture	88	76	12	15.8
Transportation	48	43	5	11.6
Residential and tertiary	96	80	16	20
Energy sector	28	26	2	7.7
TOTAL	260	225	35	15.6

Figures in millions of oil-equivalent tons

Estimated figures for 1985

French Energy Policy. p. 9

The United States of Mexico

Population Demography

AREA AND DENSITY OF MEXICO'S POPULATION

Place	Area (km²)	Population*	Population Density‡ (km²)
MEXICO	1,972,547†	66,943,976	34.0
Aguascalientes	5,589	477,628	85.5
Aguascalientes			
Baja California Norte	70,113	1,307,211	18.6
Tijuana			
Mexicali			
Baja California Sur	73,677	193,250	2.6
La Paz			
Campeche	51,833	368,748	7.1
Campeche			
Chiapas	73,887	2,110,203	28.6
Tuxtla Gutiérrez			
Chihuahua	247,087	2,176,505	8.8
Ciudad Juárez			
Chihuahua			
Coahuila	151,571	1,516,726	10.0
Saltillo			
Colima	5,455	344,571	63.2
Colima			
Distrito Federal	1,499	8,988,230	5,996.2
México			
Durango	119,648	1,273,160	10.6
Victoria de Durango			
Guanajuato	30,589	2,991,371	97.8
León			
Guanajuato			
Guerrero	63,794	2,171,184	34.0
Chilpancingo de los Bravo			
Acapulco de Juárez			
Hidalgo	20,987	1,475,155	70.3
Pachuca de Soto			
Jalisco	80,137	4,512,152	56.3
Guadalajara			
México	21,461	7,311,884	340.7
Toluca de Lerdo			

(continued....)

Table 19 AREA AND DENSITY OF MEXICO'S POPULATION (CONTINUED)

Place	Area (km^2)	Population*	Population Density‡ (km^2)
Michoacán	59,864	3,030,312	50.6
Morelia			
Morelos	4,941	903,596	182.9
Cuernavaca			
Nayarit	27,621	759,212	27.8
Tepic			
Nuevo León	64,555	2,484,972	38.5
Monterrey			
Oaxaca	95,364	2,361,721	24.8
Oaxaca de Juárez			
Puebla	33,919	3,238,227	95.5
Heróica Puebla de Zaragoza			
Querétaro	11,769	680,726	57.8
Querétaro			
Quintana Roo	50,350	149,289	3.0
Chetumal			
San Luis Potosí	62,848	1,692,833	26.9
San Luis Potosí			
Sinaloa	58,092	1,922,407	33.1
Mazatlán			
Culiacán Rosales			
Sonora	184,934	1,558,456	8.4
Hermosillo			
Tabasco	24,661	1,110,317	45.0
Villahermosa			
Tamaulipas	79,829	2,008,165	25.2
Ciudad Victoria			
Tlaxcala	3,914	513,817	131.3
Tlaxcala de Xicohtencatl			
Veracruz	72,815	5,167,123	71.0
Veracruz Llave			
Jalapa Enríquez			
Yucatán	39,340	1,012,103	25.7
Mérida			
Zacatecas	75,040	1,132,722	15.1
Zacatecas			

* June 1978, unless otherwise specified
† Excluding uninhabited islands (5,363 km^2)
‡ Population Distribution: 64% urban; 36% rural

Energy In Mexico. SERI. April, 1980. D. Hawkins.

Table 20

DISTRIBUCION DEL CONSUMO DE ENERGIA PRIMARIA
AÑO 1977

UNIDADES: MTEC

	Fuente energética	Nuclear	Hidráulica	Gas natural	Carbón	Petróleo	Sistema eléctrico	Totales
Sectores de consumo energético	Doméstico, servicios y agrícola	—	—	0,3	0,4	10,6	3,5	14,8
	Transporte	—	—	—	—	19,3	0,2	19,5
	Industria	—	—	1,2	7,7	17,0	6,1	32,0
	No energético y Bunkers	—	—	—	—	7,6	—	7,6
	Total	—	—	1,5	8,1	54,5	9,8	73,9
Conversión en energía eléctrica		0,7	4,9	0,1	2,5	3,2		
Pérdidas y consumos propios (*)		1,3	9,1 (**)	0,1	4,6	7,5	1,6	24,2
Consumo total de energía primaria		2,0	14,0	1,7	15,2	65,2	11,4	98,1

(*) Principalmente pérdidas de conversión de energía solar térmica en electricidad.
(**) El método de cálculo usado por el P.E.N. y también por la O.C.D.E. expresa la energía hidráulica en unidades de energía térmica equivalentes para producir la energía eléctrica; de ahí el elevado valo. de las pérdidas en energía hidráulica.

Boletín Informativo #88. Madríd, 1979, December

"La Energía Solar en España".

Table 21

Ideal way of redistributing the consumption of energy among different sectors.

(Spain)

Sector	Tipo fuente energética	CONSUMO TERMICO EN MTEC			
		<80°C.	80<T <260°C	>260°C	TOTAL
Industrial ...	Gasóleo + + fuel-oil Gas natural G.L.P.	3,52 0,17 0,11	5,91 0,60 0,18	5,64 0,43 0,17	15,07 1,20 0,46
Doméstico, agrícola, servicios	Gasóleo + + fuel-oil G.L.P. Electricidad	2,19 2,92 0,35	— — —	— — —	2,19 2,92 0,35
Transporte ...		—	—	—	—
No energético.		—	—	—	—
Totales		9,26	6,69	6,24	22,19
% sobre total de consumo primario ...		9,4	6,8	6,4	22,6

Estas cifras representan un tope teórico difícilmente alcanzable, pero dan una primera idea de las posibilidades de sustitución, en los procesos citados, de otras energías por la energía solar.

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